US 20200045634A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2020/0045634 A1**

KNECKT et al. (43) **Pub. Date: Feb. 6, 2020**

(54) **TARGET WAKE TIME SCHEME FOR MULTICAST COMMUNICATION**

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(21) Appl. No.: **16/403,983**

(22) Filed: **May 6, 2019**

Related U.S. Application Data

(60) Provisional application No. 62/714,416, filed on Aug. 3, 2018.

Publication Classification

(51) **Int. Cl.**

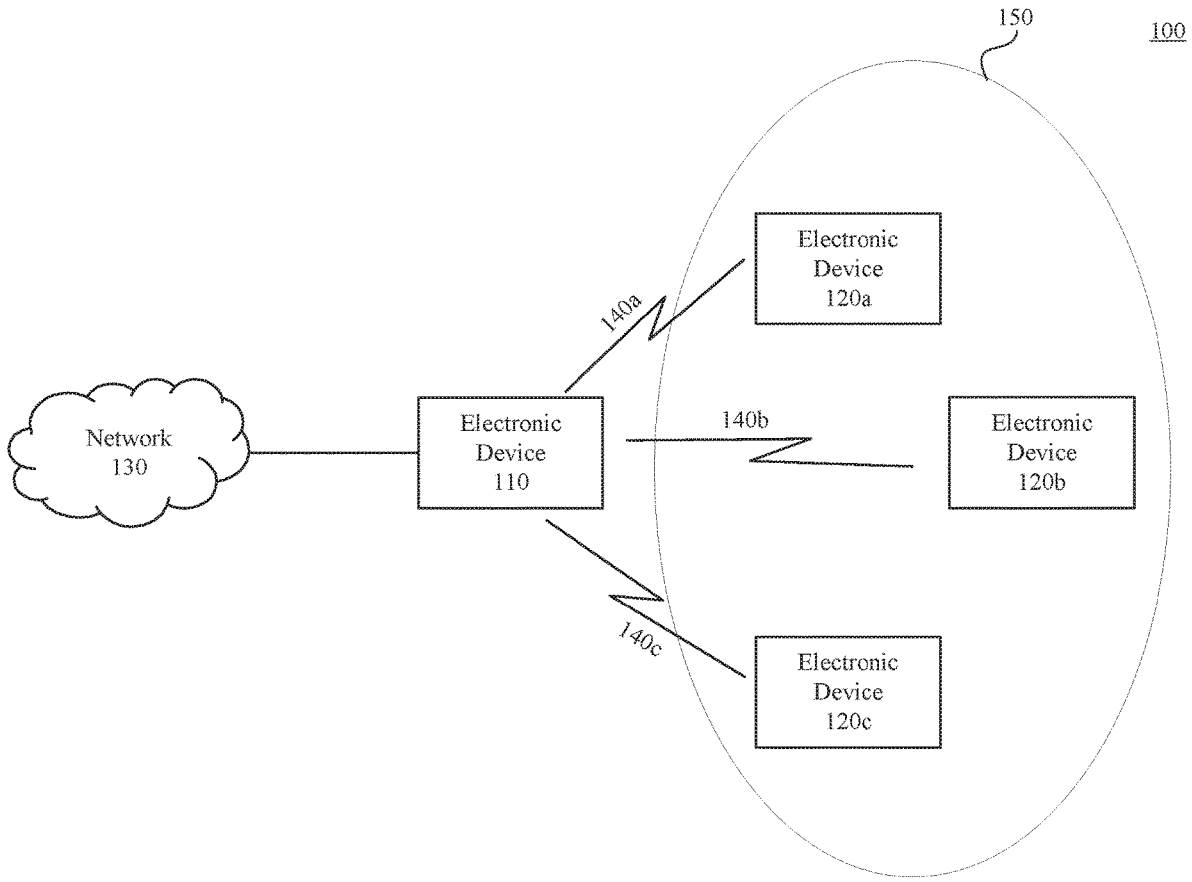
H04W 52/02	(2006.01)
H04L 12/18	(2006.01)
H04W 40/24	(2006.01)

(52) **U.S. Cl.**

CPC ***H04W 52/0229*** (2013.01); ***H04W 40/244*** (2013.01); ***H04W 52/0216*** (2013.01); ***H04L 12/189*** (2013.01)

(57) **ABSTRACT**

Some embodiments of this disclosure include apparatuses and methods for implementing a target wake time (TWT) technique for multicast communication. For example, some embodiments relate to a method including configuring a target wake time (TWT) process for delivering one or more multicast packets to a group of electronic devices. The method further includes determining that a service period associated with the TWT process has started and transmitting, in accordance with the TWT process, the one or more multicast packets during the service period, where the one or more transmitted multicast packets are addressed to the group of electronic devices.



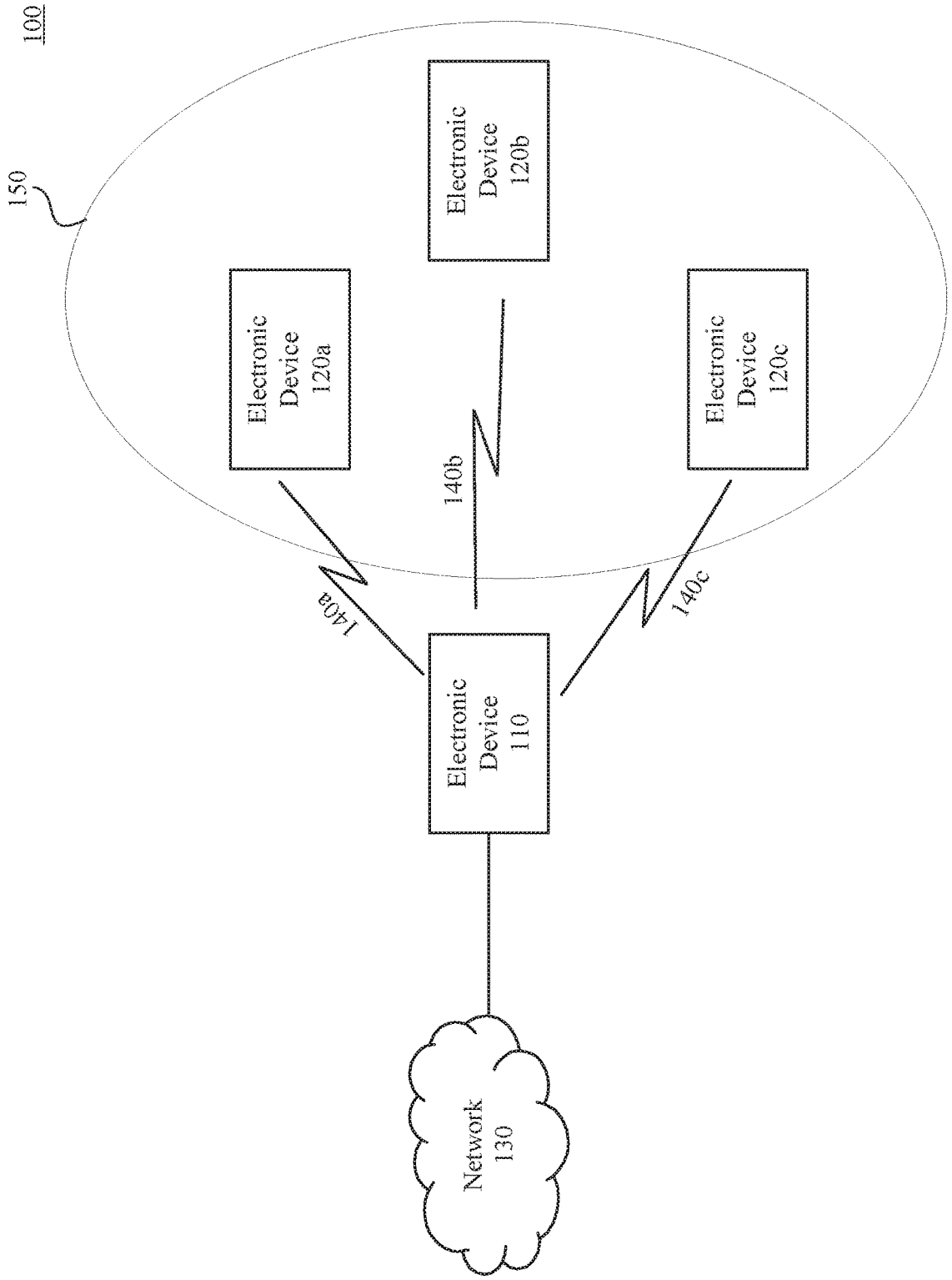

100
150
Electronic Device 120b
Electronic Device 120a
Electronic Device 120c
140b
140a
140c
Electronic Device 110
Network 130

FIG. 1

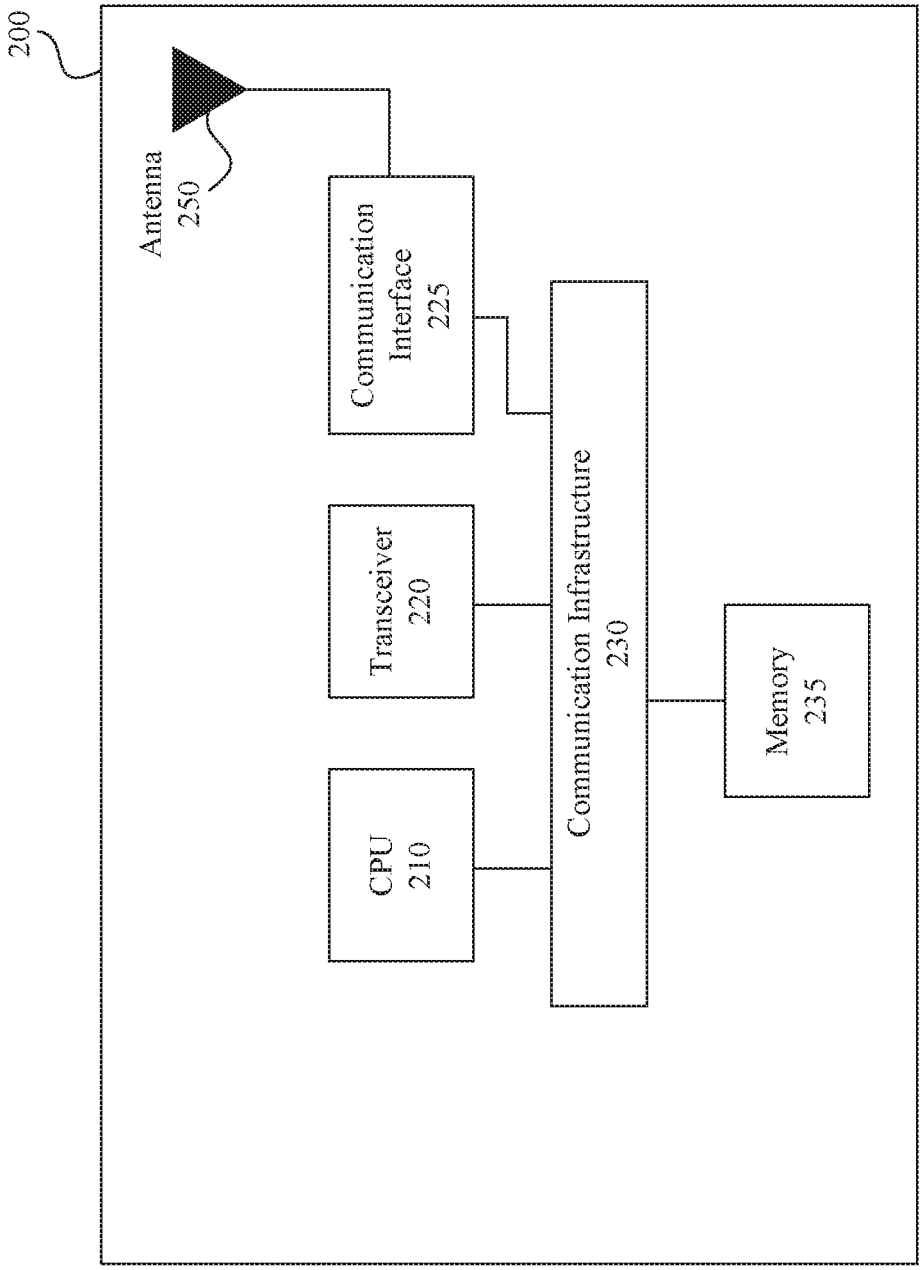

200
Antenna
250
Communication Interface
225
Transceiver
220
CPU
210
Communication Infrastructure
230
Memory
235

FIG. 2

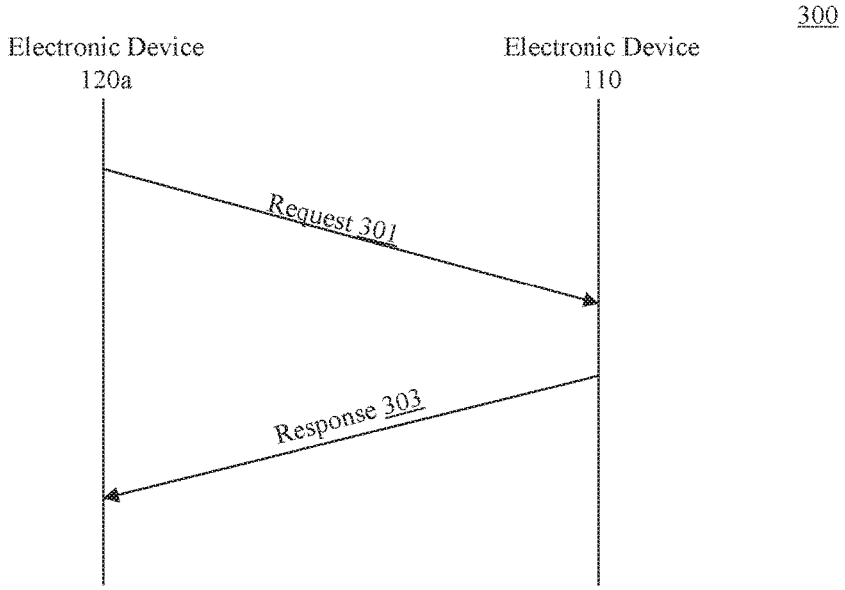

300
Electronic Device
120a
Electronic Device
110
Request 301
Response 303

FIG. 3A

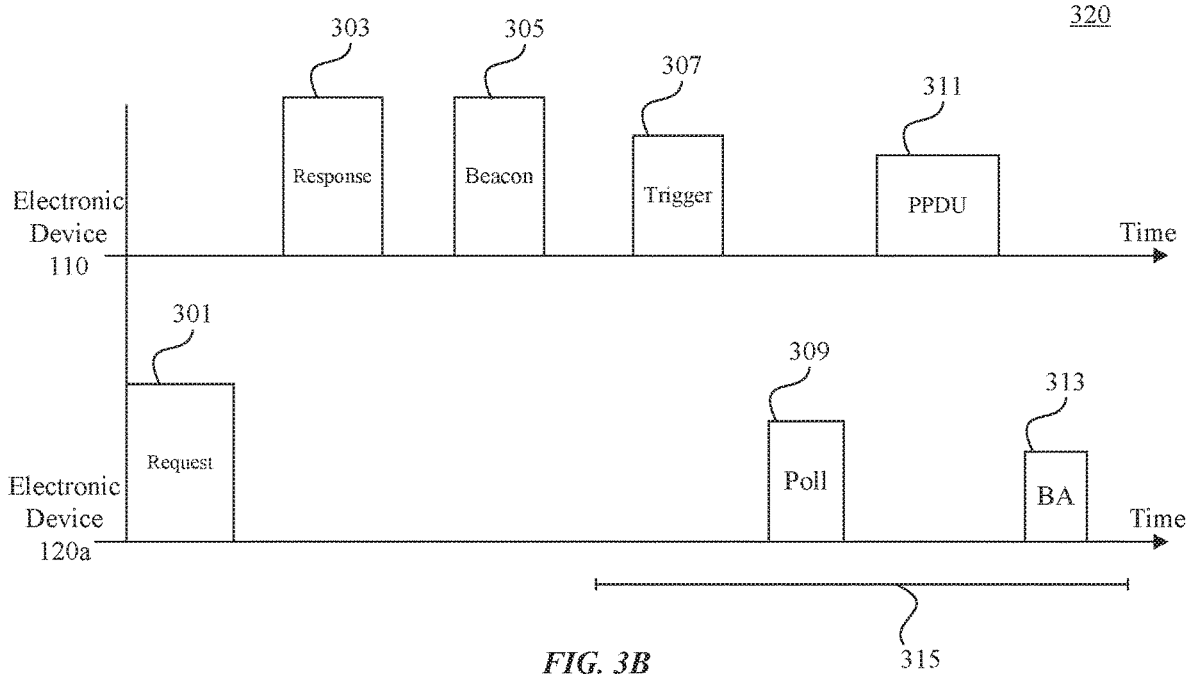

320
303
305
307
311
Response
Beacon
Trigger
PPDU
Electronic
Device
110
Time
301
309
313
Request
Poll
BA
Electronic
Device
120a
Time
315

FIG. 3B

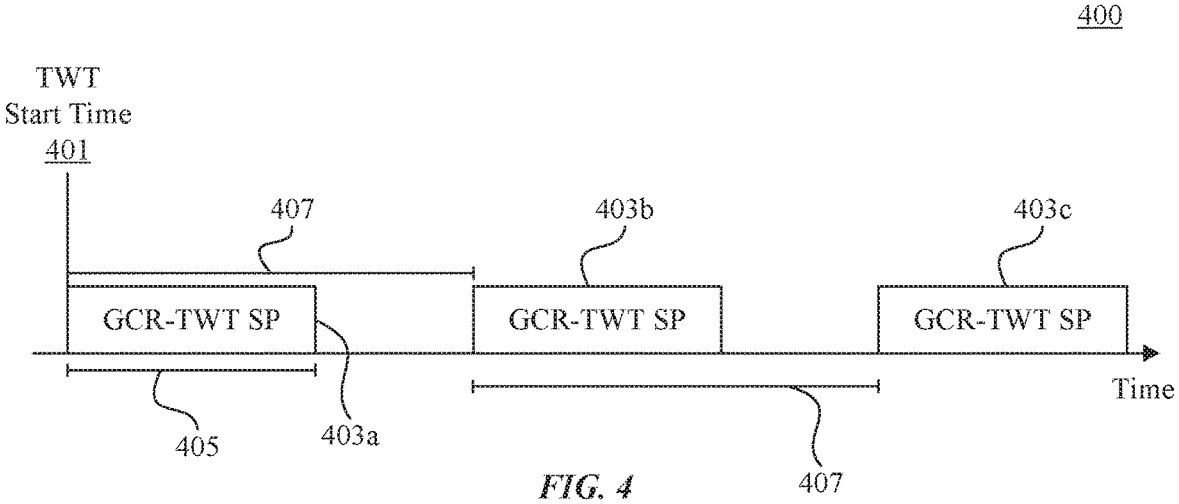

400
TWT
Start Time
401
407
403b
403c
GCR-TWT SP
GCR-TWT SP
GCR-TWT SP
Time
405
403a
407

FIG. 4

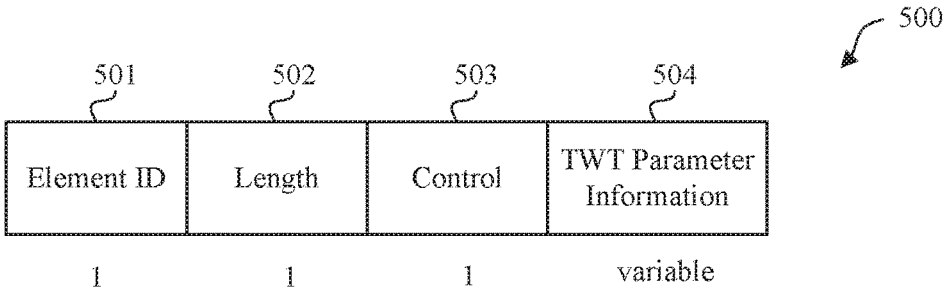

500
501
502
503
504
Element ID
Length
Control
TWT Parameter Information
1
1
1
variable

FIG. 5A

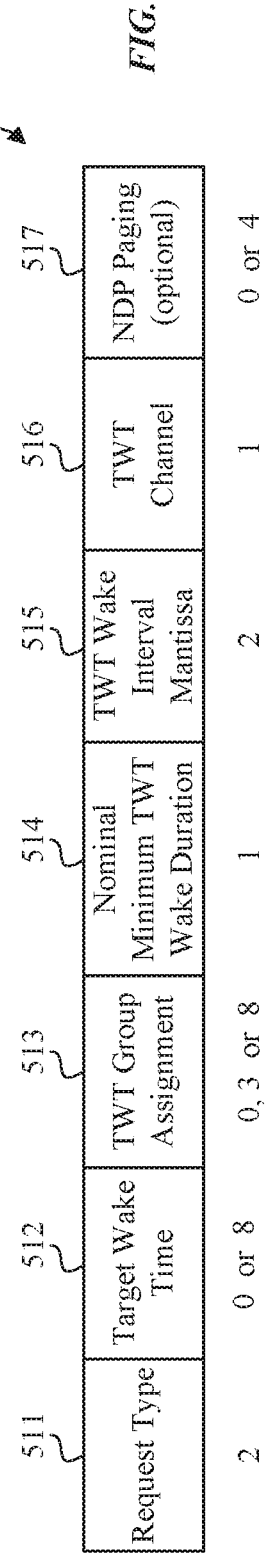


FIG. 5B

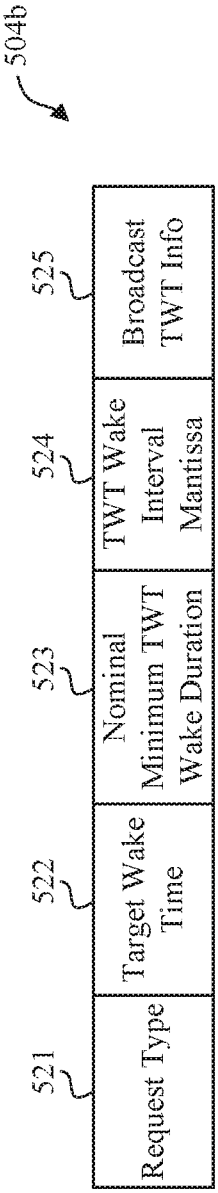


FIG. 5C

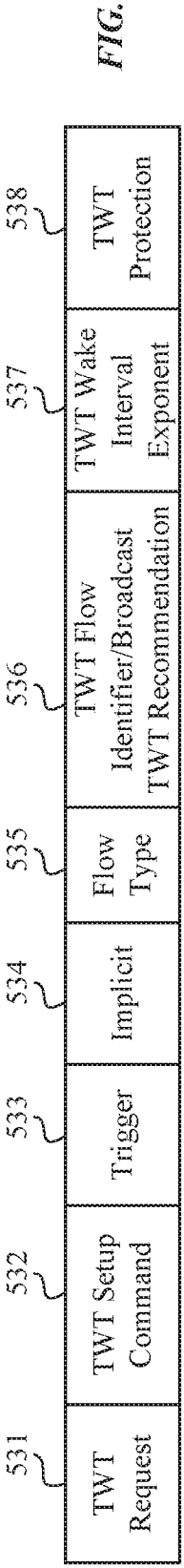


FIG. 5D

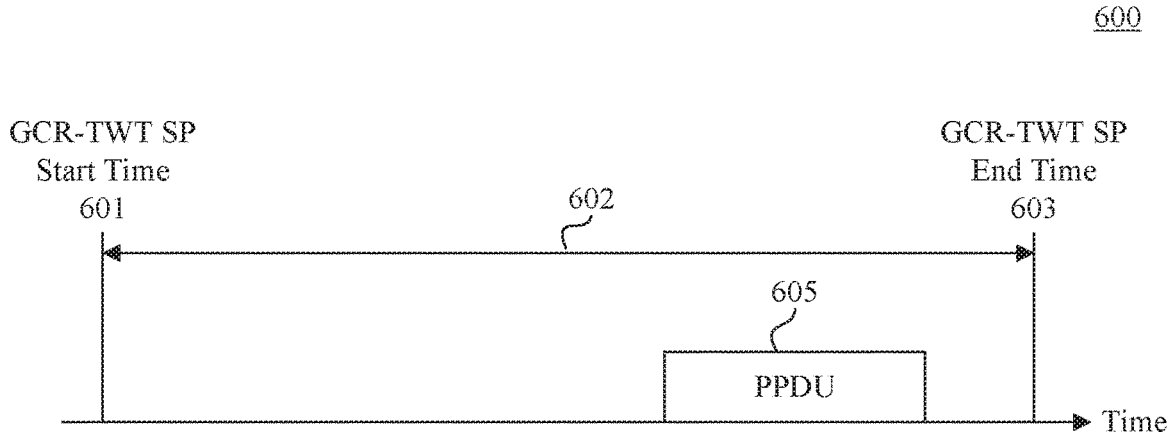

600
GCR-TWT SP
Start Time
601
602
GCR-TWT SP
End Time
603
605
PPDU
Time

FIG. 6A

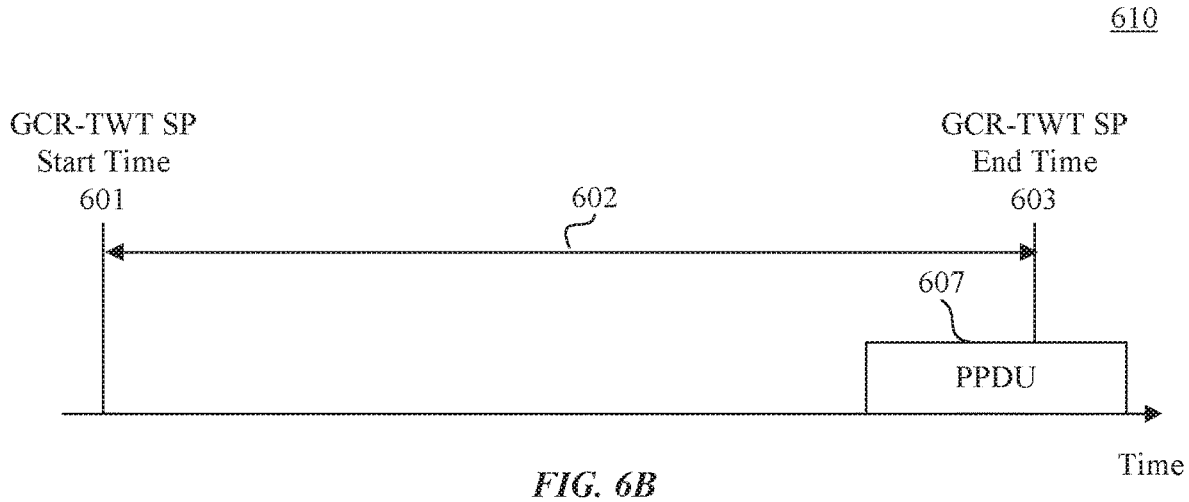

610
GCR-TWT SP
Start Time
601
602
GCR-TWT SP
End Time
603
607
PPDU
Time

FIG. 6B

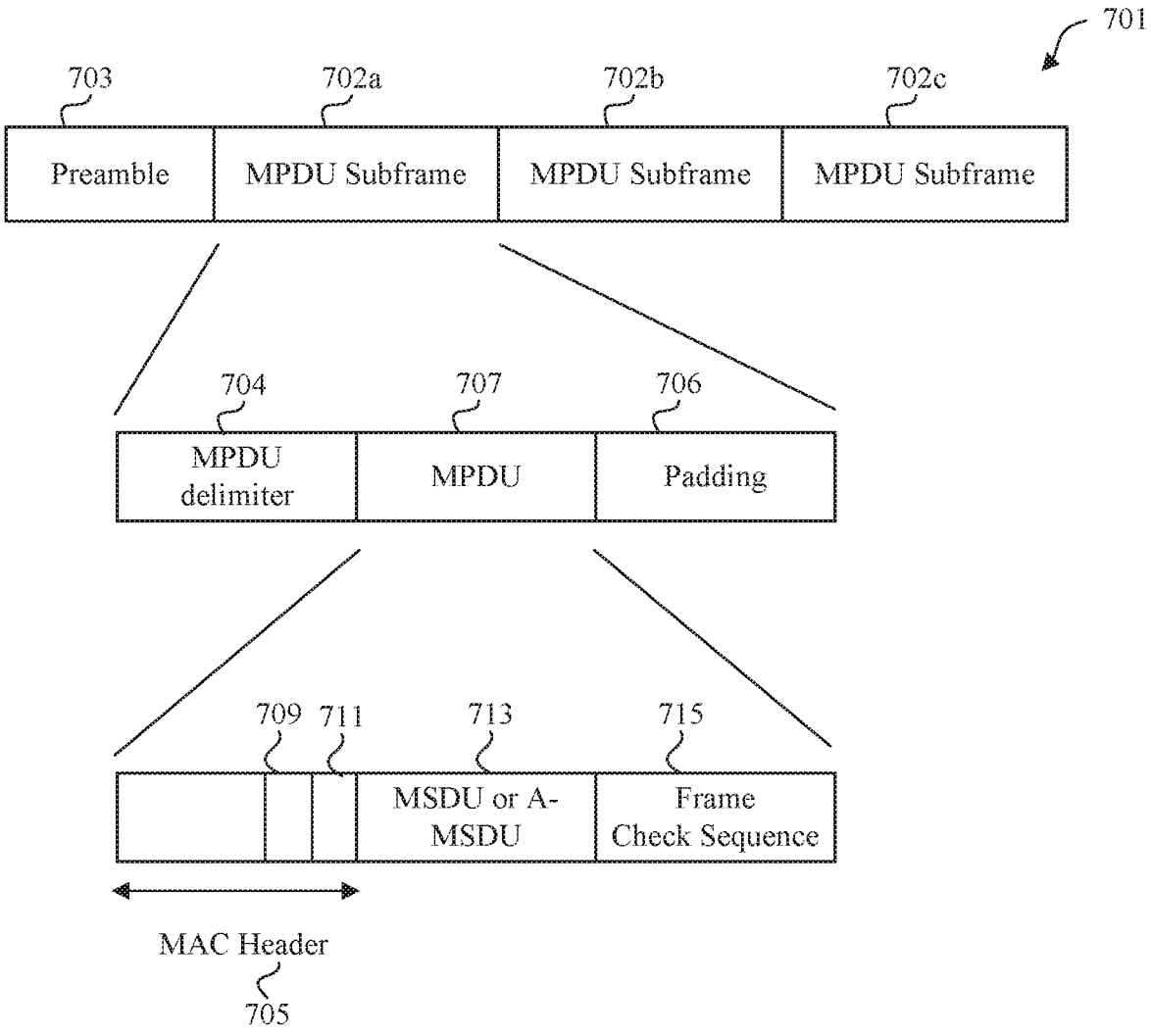

701
703
702a
702b
702c
Preamble
MPDU Subframe
MPDU Subframe
MPDU Subframe
704
707
706
MPDU delimiter
MPDU
Padding
709
711
713
715
MSDU or A-MSDU
Frame Check Sequence
MAC Header
705

FIG. 7

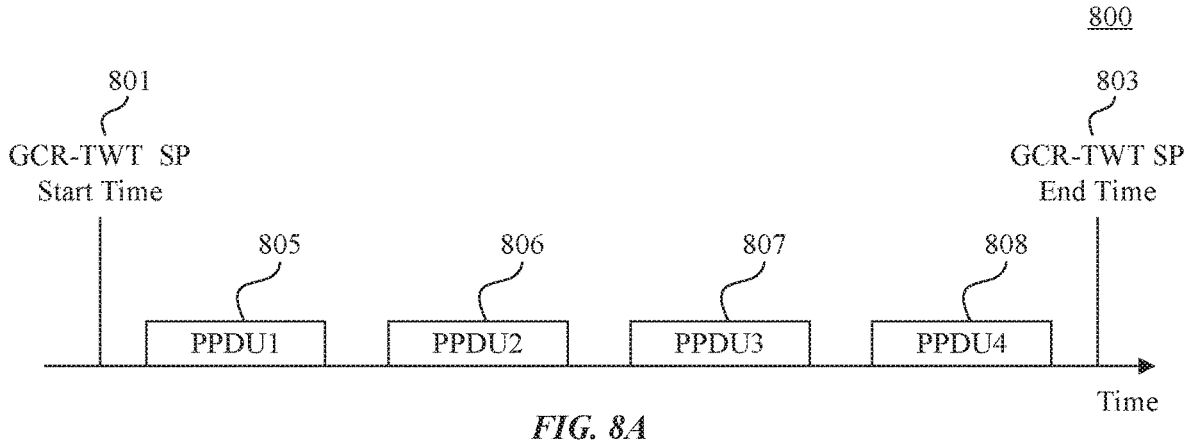


FIG. 8A

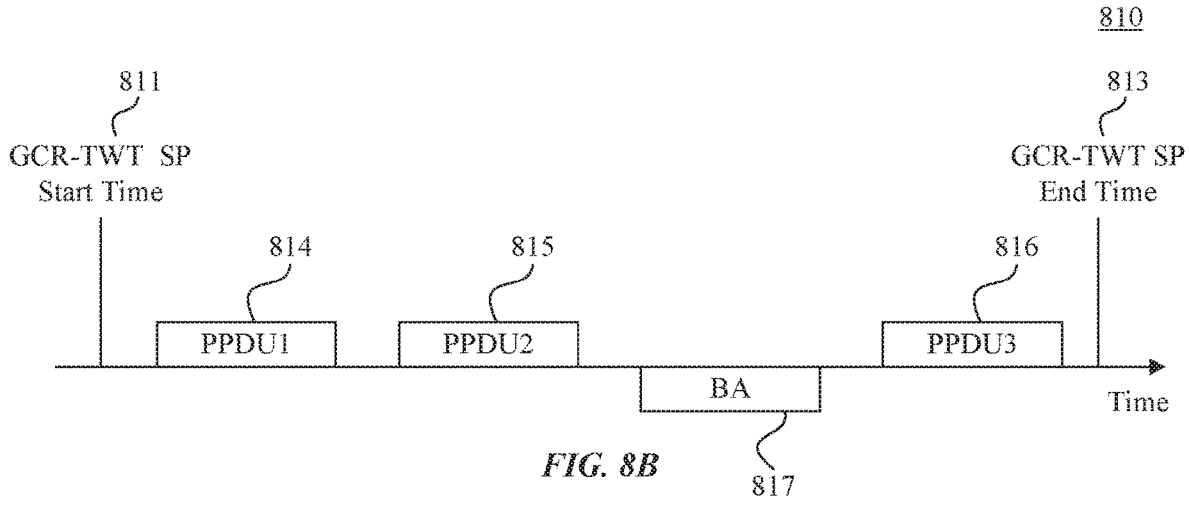


FIG. 8B

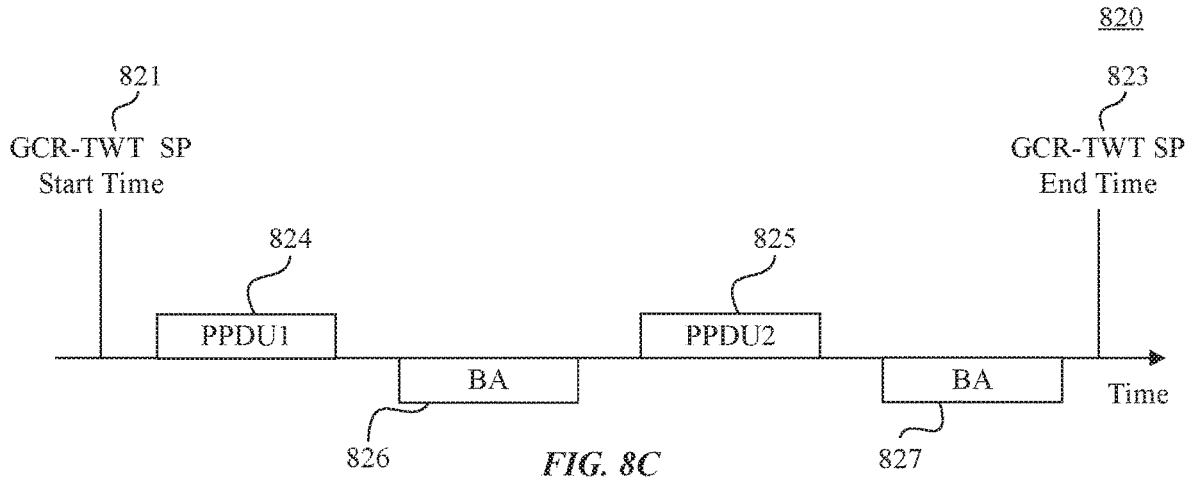


FIG. 8C

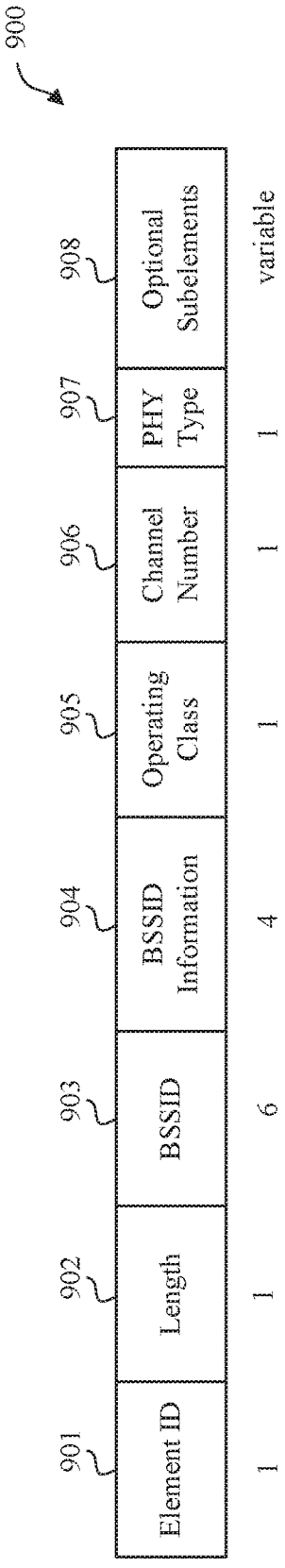

900
901
Element ID
1
902
Length
1
903
BSSID
6
904
BSSID Information
4
905
Operating Class
1
906
Channel Number
1
907
PHY Type
1
908
Optional Subelements
variable

FIG. 9A

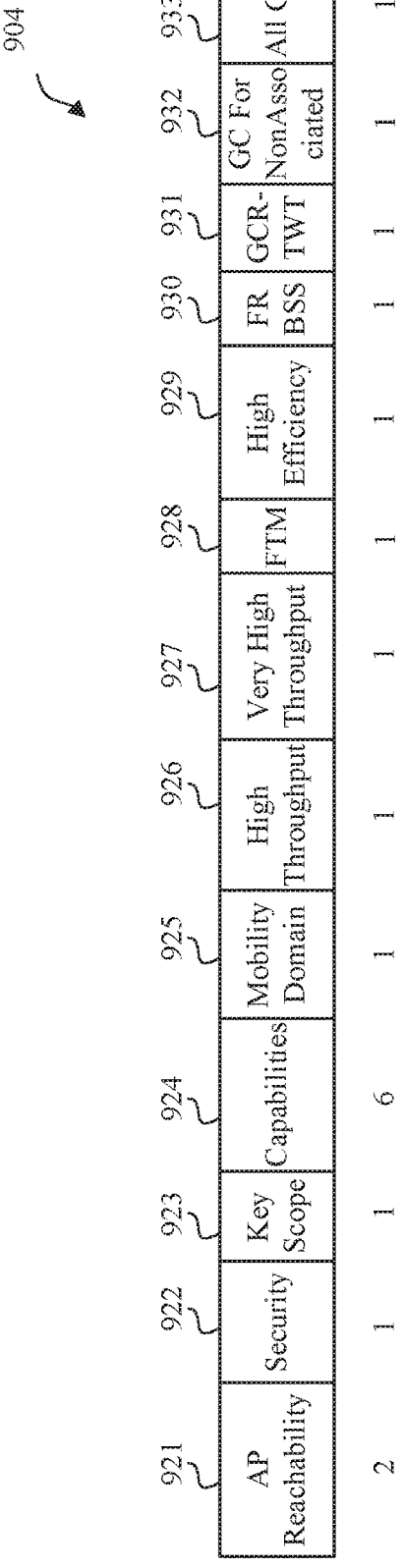

904
921
AP Reachability
2
922
Security
1
923
Key Scope
1
924
Capabilities
6
925
Mobility Domain
1
926
High Throughput
1
927
Very High Throughput
1
928
FTM
1
929
High Efficiency
1
930
FR BSS
1
931
GCR-TWT
1
932
GC For NonAssociated
1
933
All GC
1
934
Reserved
13

FIG. 9B

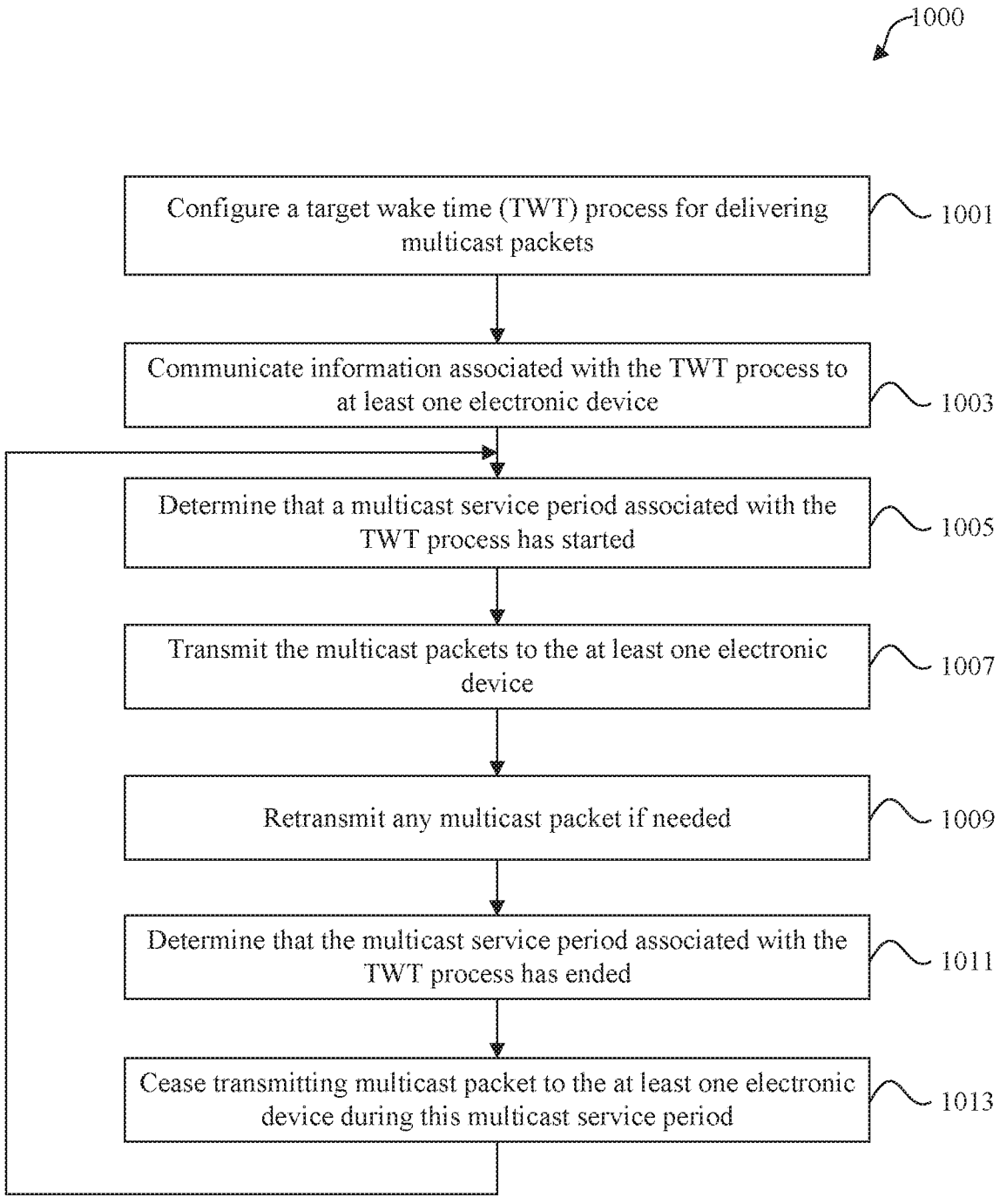

1000
Configure a target wake time (TWT) process for delivering multicast packets
1001
Communicate information associated with the TWT process to at least one electronic device
1003
Determine that a multicast service period associated with the TWT process has started
1005
Transmit the multicast packets to the at least one electronic device
1007
Retransmit any multicast packet if needed
1009
Determine that the multicast service period associated with the TWT process has ended
1011
Cease transmitting multicast packet to the at least one electronic device during this multicast service period
1013

FIG. 10

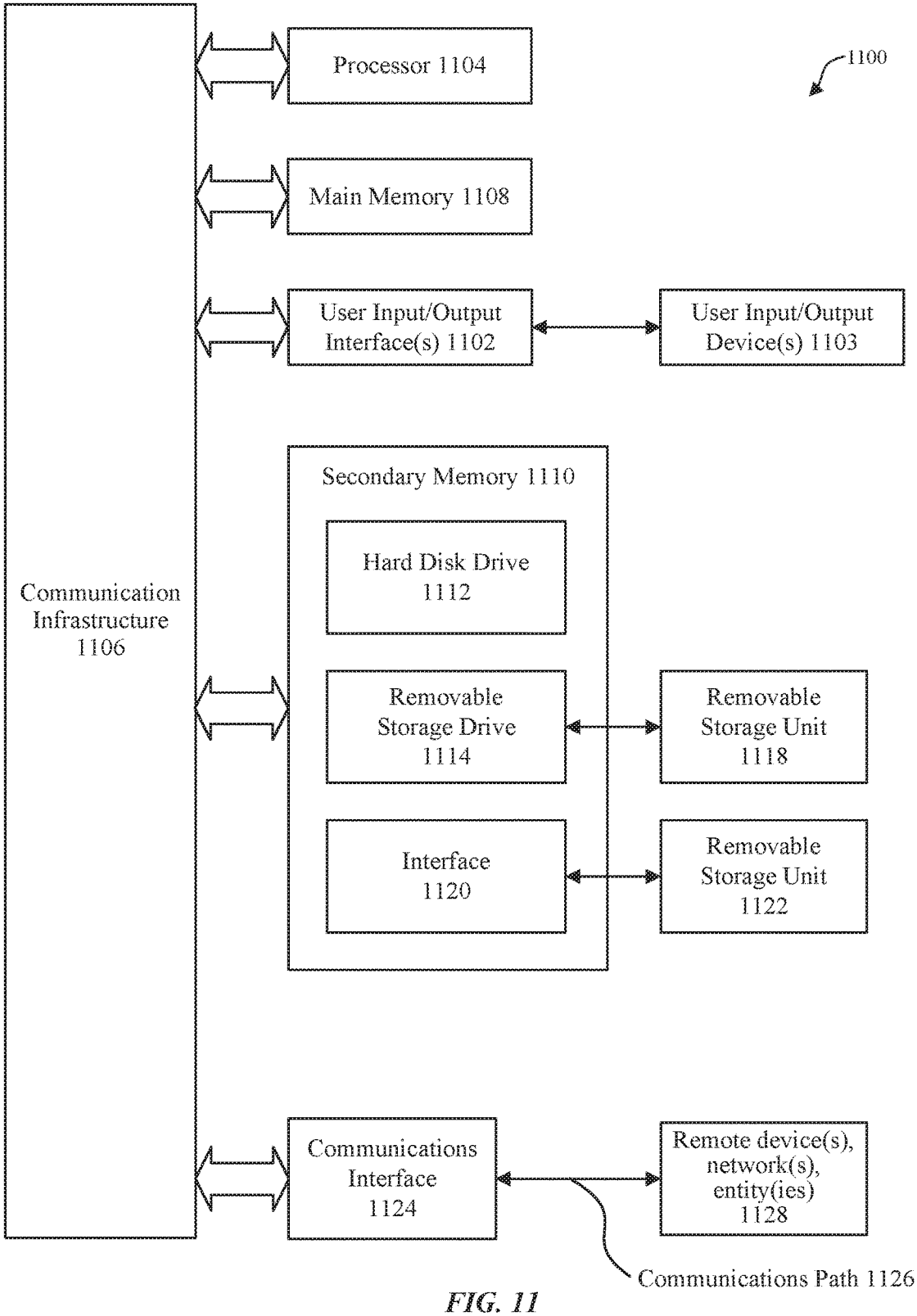

1100
Processor 1104
Main Memory 1108
User Input/Output Interface(s) 1102
User Input/Output Device(s) 1103
Secondary Memory 1110
Hard Disk Drive 1112
Removable Storage Drive 1114
Removable Storage Unit 1118
Interface 1120
Removable Storage Unit 1122
Communication Infrastructure 1106
Communications Interface 1124
Remote device(s), network(s), entity(ies) 1128
Communications Path 1126

FIG. 11

TARGET WAKE TIME SCHEME FOR MULTICAST COMMUNICATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Patent Application No. 62/714,416, filed on Aug. 3, 2018, which is hereby incorporated by reference in its entirety.

BACKGROUND

Field

[0002] The described embodiments generally relate to channel access in wireless communications.

Related Art

[0003] One wireless communication technique for providing content to multiple devices can use a multicast group. For example, one device that is the source of the multicast data (e.g., source device, source node, or source) can transmit the multicast data to multiple devices that are members of the multicast group (e.g., sink devices, sink nodes, or sinks.) By using the multicast group and multicast transmission, the resources for, for example, generating the data, processing the data, and communicating the data can be shared between multiple devices. Therefore, the overall air time, the air interface capacity, and power consumption can be improved.

[0004] According to some examples, the multicast communication can be based on communication techniques compatible with Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards. For example, the multicast communication can be used within a wireless local area Network (WLAN). In this example, an access point (AP) can operate as the source device. However, the multicast communication mechanism can have sources of inefficiencies. For example, the multicast frames can be transmitted with some delays (e.g., transmitted after Delivery Traffic Indication Map (DTIM) beacons with long DTIM intervals.) These delays can be too long for real time traffic. In other examples, the source device might not indicate the addresses of the group addressed multicast frames that are transmitted after DTIM beacons. Therefore, the sink devices receive all transmitted frames, which results in more power consumption.

SUMMARY

[0005] Some embodiments of this disclosure include apparatuses and methods for implementing a target wake time (TWT) scheme (or technique) for multicast communication.

[0006] Some embodiments relate to a method including configuring a target wake time (TWT) process for delivery of one or more multicast packets to a group of electronic devices. The method further includes determining that a service period associated with the TWT process has started and transmitting, in accordance with the TWT process, the one or more multicast packets during the service period, where the one or more transmitted multicast packets are addressed to the group of electronic devices.

[0007] Some embodiments relate to an electronic device. The electronic device includes a transceiver that transmits and receives wireless communications and one or more processors communicatively coupled to the transceiver. The one or more processors configure a target wake time (TWT) process for delivering one or more multicast packets to a group of electronic devices and communicate, using the transceiver, information associated with the TWT process to at least one electronic device in the group of electronic devices. The one or more processor further determine that a service period associated with the TWT process has started and transmit, using the transceiver and in accordance with the TWT process, the one or more multicast packets to the group of electronic devices during the service period.

[0008] Some embodiments relate to a non-transitory computer-readable medium storing instructions. When the instructions are executed by a processor of an electronic device, the instructions cause the processor to perform operations including configuring a target wake time (TWT) process for delivering one or more multicast packets to a group of electronic devices. Configuring the TWT process includes determining a TWT schedule in response to a request for the TWT process from at least one electronic device in the group of electronic devices or determining a broadcast TWT schedule. The operations further include determining that a service period associated with the TWT process has started and transmitting the one or more multicast packets to the group of electronic devices during the service period.

[0009] This Summary is provided merely for purposes of illustrating some embodiments to provide an understanding of the subject matter described herein. Accordingly, the above-described features are merely examples and should not be construed to narrow the scope or spirit of the subject matter in this disclosure. Other features, aspects, and advantages of this disclosure will become apparent from the following Detailed Description, Figures, and Claims.

BRIEF DESCRIPTION OF THE FIGURES

[0010] The accompanying drawings, which are incorporated herein and form part of the specification, illustrate the presented disclosure and, together with the description, further serve to explain the principles of the disclosure and enable a person of skill in the relevant art(s) to make and use the disclosure.

[0011] FIG. **1** illustrates an example system implementing a multicast communication with TWT, according to some embodiments of the disclosure.

[0012] FIG. **2** illustrates a block diagram of an example wireless system of an electronic device implementing a multicast communication with TWT, according to some embodiments of the disclosure.

[0013] FIGS. **3**A-**3**B illustrate example operations of communication between a sink electronic device and a source electronic device, according to some embodiments of the disclosure.

[0014] FIG. **4** illustrates an exemplary TWT flow for multicast communication, according to some embodiments of the disclosure.

[0015] FIGS. **5**A-**5**D illustrate an exemplary TWT element format for implementing TWT for multicast communication, according to some embodiments of the disclosure.

[0016] FIGS. **6**A-**6**B illustrate two example implementations for transmission of multicast packets within a multicast service period, according to some embodiments of the disclosure.

[0017] FIG. **7** illustrates an example frame format, according to some embodiments of the disclosure.

[0018] FIGS. **8**A-**8**C illustrate exemplary operations of a source electronic device implementing TWT scheme with multicast communication, according to some embodiments of the disclosure.

[0019] FIGS. **9**A-**9**B illustrate an exemplary neighbor report element format, according to some embodiments of the disclosure.

[0020] FIG. **10** illustrates an example method for a wireless system supporting implementing TWT process/scheme in multicast communication, according to some embodiments of the disclosure.

[0021] FIG. **11** is an example computer system for implementing some embodiments or portion(s) thereof.

[0022] The present disclosure is described with reference to the accompanying drawings. In the drawings, generally, like reference numbers indicate identical or functionally similar elements. Additionally, generally, the left-most digit (s) of a reference number identifies the drawing in which the reference number first appears.

DETAILED DESCRIPTION

[0023] Some embodiments of this disclosure include apparatuses and methods for implementing a target wake time (TWT) scheme (or technique) for multicast communication. Multicast communication (e.g., Groupcast with retries (GCR)) is a scalable and reliable transmission mechanism for transmitting multicast packets. Enabling the TWT scheme with the multicast communication can reduce power consumption at receiver devices and shorten transmission delays, according to some embodiment of this disclosure. Additionally, some embodiments of this disclosure describe methods for early termination of multicast service periods to optimize power consumption and reliable reception of multicast packets.

[0024] In general, the information communicated between the electronic devices in the disclosed embodiments may be conveyed in packets or frames that are transmitted and received by radios in the electronic devices in accordance with a communication protocol such as an Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard, Bluetooth™ (from the Bluetooth Special Interest Group of Kirkland, Wash.), a cellular-telephone communication protocol, and/or another type of wireless interface (such as a peer-to-peer communication technique. Some of the embodiments are discussed with respect to wireless local area Network (WLAN), but the embodiments of this disclosure are not limited to WLAN.

[0025] According to some embodiments, the multicast communication can be implemented using Groupcast with retries (GCR), which is a scalable transmission mechanism that improves reliability of multicast packet delivery. In the multicast communication, a source electronic device is configured to transmit multicast packets (e.g., is configured to multicast the packets) to member of a multicast group. In some examples, the multicast communication does not use any feedback (e.g., acknowledgment) from the members of the multicast group (e.g., the sink electronic devices.) In other words, no acknowledgment from the sink electronic devices is used. In these examples, the source electronic device can be configured to retransmit all or a selected group of the multicast packets without any acknowledgments.

[0026] In another example, the multicast communication can use block acknowledgments from the sink electronic devices. In this example, after transmitting the multicast packets, the source electronic device can request block acknowledgments from one or more members of the multicast group. The source electronic device may retransmit the failed multicast packet(s) to the members of the multicast group as retransmitted multicast packet(s) (e.g., group-addressed packet(s)). Yet in another example, the multicast communication can use block acknowledgments from the sink electronic devices but the source electronic device may retransmit the failed multicast packet(s) as individually addressed packet(s) to the sink electronic devices that did not receive the multicast packet(s).

[0027] Some of the embodiments of this disclosure apply the TWT scheme to the multicast communication. TWT is a function that enables, for example, a source electronic device to negotiate and/or define a specific time or a set of times for sink electronic devices to access a medium. As discussed in more detail, after a TWT schedule is configured, the source electronic device can transmit and/or retransmit multicast packets to the members of the multicast group and/or to unassociated electronic devices during the scheduled period(s). Accordingly, the members of the multicast group and/or unassociated electronic devices can be awake during the scheduled periods to receive the multicast packets and can be asleep or perform other activities outside of the scheduled periods.

[0028] FIG. **1** illustrates an example system **100** implementing a multicast communication with TWT, according to some embodiments of the disclosure. Example system **100** is provided for the purpose of illustration only and does not limit the disclosed embodiments. System **100** may include, but is not limited to, electronic devices **110**, **120** and network **130**. Electronic devices **110** and **120***a*-**120***c* may include, but are not limited to, WLAN stations such as wireless communication devices, smart phones, laptops, desktops, tablets, personal assistants, monitors, and televisions. Electronic devices **110** and **120***a*-**120***c* may support latency sensitive applications (e.g., video and/or audio streaming.)

[0029] According to some embodiments, electronic device **110** may include a source electronic device **110** and electronic devices **120***a*-**120***c* may include sink electronic devices. For example, source electronic device **110** may be an access point (AP) in WLAN or a source device in another source-sink scenario (e.g., in peer-to-peer communication applications.) In this example, source electronic device **110** may include, but is not limited to, WLAN electronic devices such as a wireless router, a wearable device (e.g., a smart watch), a wireless communication device (e.g., a smart phone), or a combination thereof. Network **130** may be the Internet and/or a WLAN.

[0030] Source electronic device **110** transmits multicast packets to members of multicast group **150** including electronic devices **120***a*-**120***c*. The communication between source electronic device **110** and the members of multicast group **150** can take place using wireless communications **140***a*-**140***c*. The wireless communications **140***a*-**140***c* can be based on a wide variety of wireless communication techniques. These techniques can include, but are not limited to, techniques based on IEEE 802.11, IEEE 802.11v, IEEE 802.11ax, etc. standards.

[0031] According to some embodiments, source electronic device **110** and sink electronic devices **120** are configured to

implement TWT for the multicast communication. Source electronic device **110** is configured to negotiate and/or define a specific time or a set of times for sink electronic devices **120** to access a medium. In one example, sink electronic device **120***a* transmits a request to source electronic device **110** to request for one or more multicast packets. According to some examples, the request can include a request for an individually addressed copy of the one or more multicast packets. Alternatively, the request can include a request for a multicast transmission of the one or more multicast packets. If source electronic device **110** has enough transmission capacity, source electronic device **110** may transmit a copy of the one or more multicast packets to sink electronic device **120***a* in response to the request from sink electronic device **120***a*. Source electronic device **110** can send the copy of the one or more multicast packets as individually addressed packet(s) to sink electronic device **120***a*, according to some embodiments.

[0032] If source electronic device **110** does not have enough transmission capacity, source electronic device **110** can configure a multicast communication with sink electronic device **120***a* in response to the request from sink electronic device **120***a*, according to some embodiments. Source electronic device **110** can also transmit a response to sink electronic device **120***a* indicating that sink electronic device **120***a* is a member of multicast group **150**. The response from source electronic device **110** can also include a TWT element to implement the TWT scheme by source electronic device **110** and/or sink electronic device **120***a*. The TWT element within the response from source electronic device **110** to sink electronic device **120***a* indicates to sink electronic device **120***a* that sink electronic device **120***a* is a member of multicast TWT of source electronic device **110** and/or that sink electronic device **120***a* has an individual TWT agreement to receive and/or transmit multicast packets within the time(s) designated by the TWT element.

[0033] FIG. **2** illustrates a block diagram of an example wireless system **200** of an electronic device implementing a multicast communication with TWT, according to some embodiments of the disclosure. System **200** may be any of the electronic devices (e.g., electronic devices **110**, **120**) of system **100**. System **200** includes central processing unit (CPU) **210**, transceiver **220**, communication interface **225**, communication infrastructure **230**, memory **235**, and antenna **250**. Memory **235** may include random access memory (RAM) and/or cache, and may include control logic (e.g., computer software) and/or data. CPU **210**, can include one or more processors, that together with instructions stored in memory **235** performs operations enabling a wireless system **200** of a system **100** to implement a multicast communication with TWT. In some embodiments CPU **210** and instructions in memory **235** together perform operations enabling wireless system **200** of system **100**. Transceiver **220** transmits and receives communications signals that support multicast communication with TWT functions according to some embodiments, and may be coupled to antenna **250**. Communication interface **225** allows system **200** to communicate with other devices that may be wired and/or wireless. Communication infrastructure **230** may be a bus. Antenna **250** may include one or more antennas that may be the same or different types.

[0034] FIGS. **3**A-**3**B illustrate example operations of communication between a sink electronic device and a source electronic device, according to some embodiments of the disclosure. FIGS. **3**A-**3**B may be described with regard to elements of FIG. **1**. Operation **300** of FIG. **3**A and/or operation **320** of FIG. **3**B may represent the communication between sink electronic device **120***a* and source electronic device **110**.

[0035] According to some embodiments, sink electronic device **120***a* transmits request **301** to source electronic device **110** to request for one or more multicast packets. In some examples, request **301** can include a directed multicast service (DMS) request. According to some examples, request **301** can include a request for an individually addressed copy of the one or more multicast packets. Alternatively, request **301** can include a request for a multicast transmission of the one or more multicast packets. As discussed above, if source electronic device **110** has enough transmission capacity, source electronic device **110** may transmit a copy of the one or more multicast packets to sink electronic device **120***a* in response to the request from sink electronic device **120***a*. Source electronic device **110** can transmit the copy of the one or more multicast packets as individually addressed packet(s) to sink electronic device **120***a*, according to some embodiments. For example, response **303** from source electronic device **110** can include the copy of the one or more multicast packets as individually addressed packet(s), e.g., the copy of the one or more multicast packets are transmitted as unicast transmission.

[0036] If source electronic device **110** does not have enough transmission capacity, source electronic device **110** can configure a multicast communication with sink electronic device **120***a* in response to the request from sink electronic device **120***a*, according to some embodiments. For example, if sink electronic device **120***a* is not part of multicast group **150**, source electronic device **110** can add sink electronic device **120***a* to multicast group **150**. Source electronic device **110** can transmit response **303** to sink electronic device **120***a* indicating that sink electronic device **120***a* is a member of multicast group **150**. Response **303** can also include the retransmission rule(s) supported by source electronic device **110** for this multicast group and/or for the transmission/retransmission of particular multicast packets. In other words, source electronic device **110** can inform sink electronic device **120***a* whether source electronic device **110** supports block acknowledgment (BA) for this multicast group and/or for the transmission/retransmission of particular multicast packets. If BA is supported, source electronic device **110** can inform sink electronic device **120***a* whether the retransmission(s) are multicast or unicast.

[0037] Response **303** can include a TWT element to implement the TWT scheme. According to some embodiments, sink electronic device **120***a* can negotiate with source electronic device **110** to configure the TWT schedule that is signaled in the TWT element of response **303**. Additionally or alternatively, sink electronic device **120***a* can provide the TWT schedule to source electronic device **110** in its request **301** and source electronic device **110** can confirm the TWT schedule in the TWT element. Source electronic device **110** can confirm the TWT schedule as suggested by sink electronic device **120***a* in some examples or source electronic device **110** can confirm the TWT schedule with additional changes according to other examples. For example, request **301** can include a TWT element having a TWT schedule that is suitable for sink electronic device **120***a* and/or for its traffic. In another example, source electronic device **110** can configure the TWT schedule without any information from

sink electronic device **120***a*. The TWT element within response **303** indicates to sink electronic device **120***a* that sink electronic device **120***a* is a member of multicast TWT of source electronic device **110** and/or that sink electronic device **120***a* has an individual TWT agreement to receive and/or transmit multicast packets within the time(s) designated by the TWT element.

[0038] According to some examples, the individual TWT agreement is a TWT agreement between source electronic device **110** and a sink electronic device (e.g., sink electronic device **120***a*) to use a TWT schedule individually tailored and/or transmitted to that sink electronic device (e.g., sink electronic device **120***a*) to use for multicast communication and the agreement parameters change may be done through individually addressed frames.

[0039] In addition to individual TWT agreements configured with individual sink electronic devices for multicast communication, source electronic device **110** can also set up a broadcast TWT schedule and advertise the broadcast TWT schedule to help TWT-capable devices conserve power usage during multicast communication. According to some embodiments, the broadcast TWT schedule is a TWT schedule broadcasted by source electronic device **110** to TWT-capable electronic devices such that the TWT-capable electronic devices can use the broadcast TWT schedule for multicast communication. In some examples, source electronic device **110** can advertise the broadcast TWT schedule in a beacon (e.g., beacon **305** of FIG. **3**B.) Associated electronic devices (e.g., sink electronic devices **120**) or unassociated electronic devices (e.g., electronic devices that are not associated with source electronic device **110** and/or are not part of a multicast group) can receive the broadcast TWT schedule and use the parameters of the broadcast TWT schedule to determine when to be awake to receive multicast packets from source electronic device **110**. Source electronic device **110** transmits beacon **305** without receiving any request (e.g., request **301**) from any electronic device, according to some embodiments. Additionally or alternatively, response **303** from source electronic device **110** can include the broadcast TWT schedule in response to receiving a request (e.g., request **301**) from a sink electronic device.

[0040] In some examples, sink electronic device **120***a* can use request **301** to request for multicast packets that sink electronic device **120***a* missed. For example, if sink electronic device **120***a* does not receive one or more multicast packets that sink electronic device **120***a* was to receive based on the broadcast TWT schedule, sink electronic device **120***a* can use request **301** to further request for those multicast packets.

[0041] In addition to request **301**, response **303**, and beacon **305**, operation **320** of FIG. **3**B illustrates trigger frame **307**, poll **309**, physical layer convergence protocol data unit (PPDU) **311**, block acknowledgment (BA) **313**, and multicast service period **315**. According to some embodiments, after establishing the TWT schedule for multicast communication through request **301** and response **303** and/or beacon **305**, source electronic device **110** can send multicast packets to sink electronic device **110** during multicast service period **315**. During multicast service period **315**, source electronic device **110** is configured to send trigger frame **307** to sink electronic device **120***a* to determine if sink electronic device **120***a* has transitioned to awake mode for receiving PPDU **311**, according to some embodiments. Sink electronic device **120***a* can respond to trigger frame **307** by transmitting poll frame **309** to indicate that sink electronic device **120***a* has transitioned to the awake mode. According to some embodiments, in response to poll **309**, source electronic device **110** can transmit the multicast packets (e.g., PPDU **311**) to sink electronic device **120***a*. In response to PDDU **311** and/or a block acknowledgment request within PPDU **311** or sent separately, sink electronic device **120***a* can transmit BA **313** and transition to sleep mode at the end of multicast service period **315**.

[0042] FIG. **4** illustrates an exemplary TWT flow **400** for multicast communication, according to some embodiments of the disclosure. TWT flow **400** can be based on the TWT schedule (e.g., individual TWT agreement, broadcast TWT schedule) negotiated between a source electronic device and a sink electronic device. FIG. **4** may be described with regard to elements of FIG. **1**.

[0043] TWT flow **400** includes TWT start time **401** that indicates when the TWT scheme for multicast communication starts, e.g., for sink electronic device **120***a*. TWT flow **400** further includes service periods **403***a*, **403***b*, **403***c*. Service periods **403** are the time windows where sink electronic device **120***a* will be awake because multicast packets may be transmitted during these service periods **403**. The service periods **403** can have any time duration, such as time duration of **405**. According to some examples, service periods **403***a*, **403***b*, **403***c* have the same time duration **405**. Alternatively, service periods **403***a*, **403***b*, **403***c* can have different time durations. TWT flow **400** also includes repetition intervals **407**. A repetition interval **407** may be the interval between the respective start times of consecutive service periods (e.g., the interval between the start time of service period **403***a* and the start time of service period **403***b*). When a TWT service period (SP) is not ongoing, sink electronic device **120***a* can be asleep or can perform other activities as sink electronic device **120***a* does not expect multicast packets from, for example, source electronic device **110**.

[0044] FIGS. **5**A-**5**D illustrate an exemplary TWT element format for implementing TWT for multicast communication, according to some embodiments of the disclosure. FIGS. **5**A-**5**D may be described with regard to elements of FIGS. **1** and **3**. The TWT element format illustrates the format of the TWT element transmitted by, for example, source electronic device **110** (and/or sink electronic device **120***a*) in, for example, response **303** and/or beacon **305** (in, for example, request **301**).

[0045] FIG. **5**A illustrates TWT element **500**. TWT element **500** can include any/all of different fields such as, but not limited to, element identifier (ID) **501**, length **502**, control **503**, and TWT parameter information **504**. The numbers under each field of TWT element **500** represent an exemplary size of the respective field of TWT element **500** in octets. TWT parameter information **504** can have different formats depending on whether TWT element **500** is associated with an individual TWT agreement or TWT element **500** is associated with a broadcast TWT schedule.

[0046] FIG. **5**B illustrates the format of TWT parameter information **504***a* when TWT element **500** is used as the individual TWT agreement. FIG. **5**C illustrates the format of TWT parameter information **504***b* when TWT element **500** is used as the broadcast TWT schedule. According to some embodiments, TWT parameter information **504***a* is used as the individual TWT agreement when a Broadcast field in control **503** is "0". In these examples, TWT parameter

information **504***b* is used as the broadcast TWT schedule when the Broadcast field in control **503** is "1".

[0047] As illustrated in FIG. **5**B, TWT parameter information **504***a* can include, but is not limited to, any/all of request type **511**, target wake time **512**, TWT group assignment **513**, nominal minimum TWT wake duration **514**, TWT wake interval mantissa **515**, TWT channel **516**, and optional null data packet (NDP) paging **517**. The numbers under each field of TWT parameter information **504***a* represents exemplary size of the respective field of TWT parameter information **504***a* in octets. These fields of TWT parameter information **504***a* define and configure the TWT schedule for the implementing the TWT scheme for multicast communication between source electronic device **110** and sink electronic device **120***a*.

[0048] Regarding the broadcast TWT schedule, and as illustrated in FIG. **5**C, TWT parameter information **504***b* can include, but is not limited to, any/all of request type **521**, target wake time **522**, nominal minimum TWT wake duration **523**, TWT wake interval mantissa **524**, and broadcast TWT information **525**. The number under a field of TWT parameter information **504***b* represents an exemplary size of the respective field of TWT parameter information **504***b* in octets. These fields of TWT parameter information **504***b* define and configure the TWT schedule for the implementing the TWT scheme for multicast communication between source electronic device **110** and sink electronic device **120***a*. In this example, TWT parameter information **504***b* is associated with TWT element **500** used for communicating the broadcast TWT schedule to associated and/or unassociated TWT-capable sink electronic devices.

[0049] According to some embodiments, request type **511** of TWT parameter information **504***a* and/or request type **521** of TWT parameter information **504***b* can include one or more fields. For example, as illustrated in FIG. **5**D, request type **511** and/or **521** can include, but is not limited to, any/all of TWT request subfield **531** (with length of, for example, 1 bit), TWT setup command subfield **532** (with length of, for example, 3 bits), trigger subfield **533** (with length of, for example, 1 bit), implicit subfield **534** (with length of, for example, 1 bit), flow type subfield **535** (with length of, for example, 1 bit), TWT flow identifier/broadcast TWT recommendation subfield **536** (with length of, for example, 3 bits), TWT wake interval exponent subfield **537** (with length of, for example, 5 bits), and TWT protection subfield **538** (with length of, for example, 1 bit). According to some examples, the TWT request subfield **531** of request type **511**/**521** can be set to "1" to indicate that TWT element **500** is being sent from a TWT requesting electronic device to a TWT responding electronic device (for example, TWT element **500** is part of request **301** of FIGS. **3**A-**3**B.) The TWT request subfield **531** of request type **511**/**521** can be set to "0" to indicate that TWT element **500** is being sent from a TWT responding electronic device to a TWT requesting electronic device (for example, TWT element **500** is part of response **303** of FIGS. **3**A-**3**B.)

[0050] According to some examples, TWT element **500** can be used to signal an individual TWT agreement to implement the TWT scheme for multicast communication. In these examples, TWT flow identifier **536** of request type **511** of TWT element **500** can be used to identify the individual TWT agreement. The source electronic device can use the same TWT flow identifier **536** for the individual TWT agreement with multiple sink electronic devices of the same multicast group for transmission of multicast packets. The individual TWT agreement can also include information regarding the retransmission mode(s) implemented by the source electronic device for this multicast group.

[0051] Additionally or alternatively, TWT element **500** can be used to signal broadcast TWT schedule to implement the TWT scheme for multicast communication. According to some examples, the broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** can be used to signal different types of multicast communication. Additionally, the broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** can be used to signal whether TWT element **500** is directed to one or more associated TWT-capable electronic devices and/or is directed to one or more unassociated TWT-capable electronic devices.

[0052] For example, the broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** can be set to a first value (for example, but not limited to, "4") to indicate that transmissions/retransmissions are for associated electronic devices and that the multicast communication can use any of a number of retransmission mechanisms. In this example, the broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** indicates that source electronic device is configured to transmit multicast packets with any of a number of retransmission mechanisms. In other words, the source electronic device may be configured to: retransmit all or a subset of multicast packets without using an acknowledgment scheme, retransmit all or a subset of multicast packets using block acknowledgment(s), or retransmit all or a subset of multicast packets using block acknowledgment where retransmissions are unicast transmissions.

[0053] As another example, broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** can be set to a second value (for example, but not limited to, "5") to indicate that transmissions/retransmissions are for associated electronic devices and that the multicast communication can use retransmission, but does not use acknowledgments. In this example, the broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** indicates that source electronic device is configured to transmit multicast packets with retransmission, but the source electronic device does not use an acknowledgment scheme. In other words, the source electronic device is configured to retransmit all or a subset of multicast packets without using acknowledgment scheme.

[0054] According to some embodiments, when broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** is set to the second value (e.g., "5"), the beacon (e.g., beacon **305** of FIG. **3**B) and/or response transmitted by the source electronic device (e.g., response **303** of FIGS. **3**A-**3**B) to transmit TWT element **500** can also include the group media access control (MAC) addresses. The group MAC addresses can include the MAC addresses of the sink electronic devices within the multicast group associated with TWT element **500**. According to some examples, the beacon and/or response include an additional element for the group MAC addresses. Additionally or alternatively, TWT element **500** can include an additional field for the group MAC addresses.

[0055] The source electronic device can change the value of TWT recommendation subfield **536** depending on changes in retransmission modes. For example, the source

electronic device may change the value of TWT recommendation subfield **536**, for example, from "4" to "5" or from "5" to "4". When the source electronic device changes the value of TWT recommendation subfield **536** from "4" to "5", the source electronic device is signaling that the retransmission mode is changed to retransmission without acknowledgments. According to some examples, before the change occurs, the source electronic device may transmit unicast responses (e.g., responses **303** of FIGS. **3**A-**3**B such as unicast directed multicast service (DMS) responses) to the sink electronic devices so that the sink electronic devices can update the retransmission mode.

[0056] When the source electronic device changes the value of TWT recommendation subfield **536** from "5" to "4", a sink electronic device that has not transmitted a request (e.g., request **301** of FIGS. **3**A-**3**B such as a DMS request) to receive multicast packets can transmit the request to the source electronic device to indicate that the sink electronic device is receiving the packets. In some examples, the retransmission mode of this sink electronic device changes when this sink electronic device receives a response (e.g., response **303** of FIGS. **3**A-**3**B such as a DMS response) from the source electronic device.

[0057] According to some embodiments and as discussed above, the source electronic device (e.g., source electronic device **110**) is configured to implement the TWT scheme for multicast communication with unassociated electronic devices (e.g., electronic devices that are not associated with source electronic device **110** and/or are not part of a multicast group). To do so, the source electronic device is configured to set up broadcast TWT schedule and transmit the broadcast TWT schedule using a beacon (e.g., beacon **305** of FIG. **3**B), according to some embodiments. In some examples, the multicast packets that are transmitted during the TWT service periods by, for example, the source electronic device can be non-encrypted such that the unassociated electronic devices can also be able to receive and decode these packets. Additionally or alternatively, the multicast packets can use higher than MAC layer encryption mechanisms and/or application specific encryption mechanisms. TWT element **500** can be configured for the cases where TWT element **500** is used for broadcast TWT schedule for unassociated electronic devices

[0058] For example, the broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** can be set to a third value (for example, but not limited to, "6") to indicate that transmissions/retransmissions are for unassociated electronic devices and that the multicast communication can use any retransmission mechanisms. In this example, the broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** indicates that source electronic device is configured to transmit multicast packets with any retransmission mechanism. In other words, the source electronic device is configured to: retransmit all or a subset of multicast packets without using an acknowledgment scheme, retransmit all or a subset of multicast packets using block acknowledgment(s), or retransmit all or a subset of multicast packets using block acknowledgment where retransmissions are unicast transmissions.

[0059] As another example, the broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** can be set to a fourth value (for example, but not limited to, "7") to indicate that transmissions/retransmissions are for unassociated electronic devices and that the multicast communication can use retransmission but does not use acknowledgments. In this example, the broadcast TWT recommendation subfield **536** of request type **521** of TWT element **500** indicates that the source electronic device is configured to: transmit multicast packets with retransmission, but the source electronic device does not use acknowledgment scheme. In other words, the source electronic device is configured to retransmit all or a subset of multicast packets without using an acknowledgment scheme.

[0060] According to some embodiments, in addition to indicating that the source electronic device offers multicast communication with unassociated electronic devices, the source electronic device may broadcast one or more MAC addresses from which the multicast packets may be transmitted. In this example, the associated and/or unassociated sink electronic devices may know from which internet protocol (IP) address desired data is transmitted. The associated and/or unassociated electronic devices may have, or have access to, an IP address-MAC address mapping to select the multicast packets from the desired MAC address. Additionally, the unassociated electronic devices may be configured to use directed multicast service (DMS) requests for delivery of multicast packets and may be able to setup block acknowledgment scheme using, for example, Add Block Acknowledgment (ADDBA) request/response frames. In some examples, the source electronic device is configured to use, for example, block acknowledgment schemes to test an unassociated electronic devices to determine whether the unassociated electronic devices is available to receive multicast packets and/or to determine whether the unassociated electronic device correctly receives the multicast packets.

[0061] FIGS. **6**A-**6**B illustrate two example implementations for transmission of multicast packets within a multicast service period, according to some embodiments of the disclosure. Operation **600** of FIG. **6**A illustrates a first implementation. Multicast service period **602** has a start time **601** and an end time **603**. Multicast service period **602** is similar to service periods **403** of FIG. **4**. In operation **600**, the multicast packets, including physical layer convergence protocol data unit (PPDU) **605** are transmitted within multicast service period **602**. Operation **610** of FIG. **6**B illustrates a second implementation. Multicast service period **602** has a start time **601** and an end time **603**. Multicast service period **602** is similar to service periods **403** of FIG. **4**. In operation **610**, the transmission of the multicast packets, including PPDU **607** starts within multicast service period **602**.

[0062] Early termination mechanisms can be used to trigger the sink electronic devices to transition to sleep mode earlier than planned and/or terminate multicast service periods earlier than planned. For example, as illustrated in more detail below, End of Service Period (EOSP) field and/or More Data field in media access control (MAC) headers of MAC protocol data units (MPDUs) of PPDUs can be used for the early termination mechanisms. Additionally or alternatively, trigger frames (e.g., trigger frame **307** of FIG. **3**B) can be used for the early termination mechanisms. For example, a trigger frame can include an additional field such as multicast Cascade Indication field (e.g., GCR-Cascade Indication field) used for the early termination mechanisms. In this example, the added multicast Cascade Indication field can be set to a first value (e.g., "1") to signal the termination of multicast service periods.

[0063] FIG. **7** illustrates an example frame format, according to some embodiments of the disclosure. For example, FIG. **7** illustrates an exemplary format of PPDU **701**. PPDU **701** can include PPDU **605** and **607** of FIGS. **6**A-**6**B or other PPDUs discussed herein, according to some examples. PPDU **701** includes one or more MAC protocol data unit (MPDU) subframes **702***a-c* and preamble **703**. Preamble **703** can include a physical layer preamble and/or physical layer header. Preamble **703** can include information used for carrier acquisition, synchronization, channel estimation, communicating frame specific parameters (e.g., coding rate, frame length, etc.), or other purposes.

[0064] MPDU subframe **702** can include fields such as, but not limited to, MPDU delimiter **704**, MPDU **707**, and padding **706**. MPDU delimiter **704** can include information on MPDU length, cyclic redundancy checks (CRC), and/or a unique pattern. Padding **706** can include frame check sequence (FCS) for error-detection and/or additional padding (e.g., 0 to 3 bytes) to compensate for different lengths of different MPDUs. MPDU **707** can include media access control (MAC) header **705**, MAC service data unit (MSDU) and/or aggregated MSDU (A-MDSU) **713**, and frame check sequence (FCS) **715**, according to some embodiments. If MPDU **707** includes A-MSDU **713**, A-MSDU **713** can include one or more A-MSDU subframes, where each A-MSDU subframe can include an A-MSDU subframe header, an MSDU, and a padding, according to some embodiments. PPDU **701** can be used to transmit multicast packets during multicast service periods. According to some examples, the multicast packets are encoded within one or more MPDUs **707**.

[0065] In some examples MAC header **705** can include More Data field **709** and End of Service Period (EOSP) field **711**. According to some examples, by setting EOSP field **711** of PPDU **701** to a first value (e.g., "1"), the source electronic device can signal to the sink electronic device that that PPDU **701** is the last transmitted PPDU in the multicast service period and no more PPDUs are transmitted in this multicast service period. Accordingly, the sink electronic device can enter the sleep mode when the sink electronic device receives PPDU **701** with EOSP field **711** set to the first value (e.g., "1") or after the sink electronic device has sent its acknowledgment of PPDU **701** (if the source electronic device requested for acknowledgment.) More Data field **709** and EOSP field **711** are discussed in more detail below.

[0066] MAC header **705** can include other fields such as, but not limited to, frame control, duration field, address(es), sequence control, and QoS control as understood by a person of ordinary skills in art. It is noted that frame format of PPDU **701** is provided as one example, and the embodiments of this disclosure are not limited to this example.

[0067] FIGS. **8**A-**8**C illustrate exemplary operations of a source electronic device implementing TWT scheme with multicast communication, according to some embodiments of the disclosure. As a convenience and not a limitation, these exemplary operations are discussed with respect to FIGS. **1** and **7**.

[0068] FIG. **8**A illustrates an exemplary operation **800** of a source electronic device implementing TWT scheme with multicast communication where the multicast communication uses retransmissions without acknowledgment retransmission rules. In other words, in the exemplary operation **800**, the source electronic device does not request acknowledgements from sink electronic devices. But the source electronic device is configured to retransmit all or a subset of multicast packets to all or a subset of sink electronic devices.

[0069] As illustrated in FIG. **8**A, a multicast service period is defined by multicast service period start time **801** and multicast service period end time **803**. The source electronic device is configured to transmit and/or retransmit PPDUs **805-808** within the multicast service period. It is noted that although these examples are discussed with respect to the source electronic device transmitting and/or retransmitting PPDUs **805-808**, these PPDUs can also be transmitted and/or retransmitted by one or more sink electronic devices.

[0070] According to some embodiments, the source electronic device may set More Data field (e.g., More Data field **709**) in the MAC headers of MPDUs of a PPDU to a first value (e.g., "1") to indicate that during the remainder of the multicast service period the source electronic device will transmit one or more MPDUs addressed to the multicast group for the first time (e.g. new MPDUs). For example, the source electronic device sets the More Data field of one or more MPDUs of PPDU **805** to "1" indicating that the following PPDU **806** includes one or more MPDUs that have not yet been transmitted. The sink electronic devices of the multicast group can check the More Data field of the received MPDUs and stay awake if the More Data field is set to the first value (e.g., "1") to be able to receive the new MPDUs.

[0071] Alternatively, the source electronic device may set More Data field (e.g., More Data field **709**) in the MAC headers of MPDUs of a PPDU to a second value (e.g., "0") to indicate that during the remainder of the multicast service period the source electronic device will only retransmit one or more MPDUs addressed to the multicast group that have previously been transmitted. For example, the source electronic device sets the More Data field of one or more MPDUs of PPDU **806** to "0" indicating that the following PPDUs (e.g., PPDUs **807** and **808**) include no new MPDUs but only retransmitted MPDUs. In this example, PPDUs **807** and **808** include retransmissions of already transmitted MPDUs. By checking the More Data field of the received MPDUs, one or more sink electronic devices of the multicast group that have already received the MPDUs can transition to sleep mode during the remainder of the multicast service period. According to some examples, the sink electronic device is configured to keep a record of transmitted and received MPDUs. Therefore, when the sink electronic device determines that it has received all transmitted MPDUs within the multicast service period, the sink electronic device can transition to sleep mode for the remainder of that multicast service period.

[0072] Further, as discussed above, the source electronic device can set the EOSP field (ESOP field **711**) in the MAC headers of the MPDUs of the last PPDU to a first value (e.g., "1") to indicate to the sink electronic devices that this PPDU is the last PPDU and no more multicast packets are transmitted during the remainder of this multicast service period. For example, the source electronic device sets the EOSP field in the MPDUs of PPDU **808** to "1" to indicate that no more multicast packets are transmitted within the remainder of this multicast service period. By checking that the EOSP field of PPDU **808** is set to "1", one or more sink electronic devices of the multicast group can transition to sleep mode during the remainder of the multicast service period.

[0073] FIG. **8**B illustrates an exemplary operation **810** of a source electronic device implementing TWT scheme with multicast communication where the multicast communication uses multicast retransmissions with block acknowledgment. In other words, in the exemplary operation **810**, the source electronic device can request for block acknowledgements from sink electronic devices and the retransmissions are multicast retransmissions.

[0074] As illustrated in FIG. **8**B, a multicast service period is defined by multicast service period start time **811** and multicast service period end time **813**. The source electronic device is configured to transmit and/or retransmit PPDUs **814-816** within the multicast service period. It is noted that although these examples are discussed with respect to the source electronic device transmitting and/or retransmitting PPDUs **814-816**, these PPDUs can also be transmitted and/or retransmitted by one or more sink electronic devices. FIG. **8**B also illustrates block acknowledgment (BA) **817** transmitted from one or more sink electronic device. Although not shown, operation **810** of the source electronic device can also include one or more requests for BA transmitted by the source electronic device. In other words, the source electronic device can be configured to transmit BA request(s) (BAR) to one or more sink electronic devices (e.g., before the sink electronic devices transmit BA **817**) to ask the sink electronic devices for BA.

[0075] According to some embodiments, the source electronic device may set More Data field (e.g., More Data field **709**) in the MAC headers of MPDUs of a PPDU to a first value (e.g., "1") to indicate that during the remainder of the multicast service period the source electronic device will transmit one or more MPDUs addressed to the multicast group for the first time. Additionally or alternatively, the source electronic device may set the More Data field to "1" to indicate that during the remainder of the multicast service period the source electronic device will request BA for the first time from one or more sink electronic devices (e.g., the source electronic device will transmit BAR for the first time for one or more sink electronic devices.) For example, the source electronic device sets the More Data field of one or more MPDUs of PPDU **814** to "1" indicating that the following PPDU **815** includes one or more MPDUs that have not yet been transmitted or the source electronic device may request BA from one or more sink electronic devices for the first time. The sink electronic devices of the multicast group can check the More Data field of the received MPDUs and stay awake if the More Data field is set to the first value (e.g., "1") to be able to receive the new MPDUs or to transmit possible requested BAs.

[0076] Alternatively, the source electronic device may set More Data field (e.g., More Data field **709**) in the MAC headers of MPDUs of a PPDU to a second value (e.g., "0") to indicate that during the remainder of the multicast service period the source electronic device will only retransmit one or more MPDUs addressed to the multicast group. Additionally or alternatively, the source electronic device may set the More Data field to "0" to indicate that during the remainder of the multicast service period the source electronic device will request BA from one or more sink electronic devices that have missed previously transmitted MPDUs during this multicast service period. The source electronic device is configured to determine the sink electronic device that has missed previously transmitted MPDUs based on the BAs that the source electronic device has previously received. For example, the source electronic device sets the More Data field of one or more MPDUs of PPDU **815** to "0" indicating that the following PPDUs (e.g., PPDU **816**) include no new MPDUs but only retransmitted MPDUs or that the following PPDU **816** includes no new request for BA but may include request(s) for BA from sink electronic devices that have missed one or more MPDUs. In this example, PPDU **816** includes retransmissions of already transmitted MPDUs.

[0077] By checking the More Data field of the received MPDUs, one or more sink electronic devices of the multicast group that have already received the MPDUs and no BA is requested from them can transition to sleep mode during the remainder of the multicast service period. However, if a sink electronic device of the multicast group receives a BA request in PPDU **815**, this sink electronic device can send BA **817** to the source electronic device. If this sink electronic device has correctly received the MPDUs, this sink electronic device can then transition to the sleep mode after transmitting BA **817**.

[0078] The source electronic device can set the EOSP field (ESOP field **711**) in the MAC headers of the MPDUs of the last PPDU to a first value (e.g., "1") to indicate to the sink electronic devices that this PPDU is the last PPDU and no more multicast packets are transmitted during the remainder of this multicast service period. For example, the source electronic device sets the EOSP field in the MPDUs of PPDU **816** to "1" to indicate that no more multicast packets are transmitted within the remainder of this multicast service period. By checking that the EOSP field of PPDU **816** is set to "1", one or more sink electronic devices of the multicast group can transition to sleep mode during the remainder of the multicast service period.

[0079] FIG. **8**C illustrates an exemplary operation **820** of a source electronic device implementing TWT scheme with multicast communication where the multicast communication uses unicast retransmissions with block acknowledgment. In other words, in the exemplary operation **820**, the source electronic device can request for block acknowledgements from sink electronic devices and the retransmissions are unicast retransmissions.

[0080] As illustrated in FIG. **8**C, a multicast service period is defined by multicast service period start time **821** and multicast service period end time **823**. The source electronic device is configured to transmit PPDUs **824-825** within the multicast service period. It is noted that although these examples are discussed with respect to the source electronic device transmitting PPDUs **824-825**, these PPDUs can also be transmitted by one or more sink electronic devices. FIG. **8**C also illustrates block acknowledgments (BAs) **826-827** transmitted from one or more sink electronic devices. Although not shown, operation **820** of the source electronic device can also include one or more requests for BA transmitted by the source electronic device. In other words, the source electronic device can be configured to transmit BA request(s) (BAR) to one or more sink electronic devices (e.g., before the sink electronic devices transmit BAs **826-827**) to ask the sink electronic devices for BA.

[0081] According to some embodiments, the source electronic device may set More Data field (e.g., More Data field **709**) in the MAC headers of MPDUs of a PPDU to a first value (e.g., "1") to indicate that during the remainder of the multicast service period the source electronic device will transmit one or more MPDUs addressed to the multicast

group for the first time. Additionally or alternatively, the source electronic device may set the More Data field to "1" to indicate that during the remainder of the multicast service period the source electronic device will request BA for the first time from one or more sink electronic devices (e.g., the source electronic device will transmit BAR for the first time from one or more sink electronic devices.) For example, the source electronic device sets the More Data field of one or more MPDUs of PPDU **824** to "1" indicating that the following PPDU **825** includes one or more MPDUs that have not yet been transmitted or the source electronic device may request BA from one or more sink electronic devices for the first time. The sink electronic devices of the multicast group can check the More Data field of the received MPDUs and stay awake if the More Data field is set to the first value (e.g., "1") to be able to receive the new MPDUs or to transmit possible requested BAs. In some examples, PPDU **824** can include and/or be followed with BAR from one or more sink electronic devices. The sink electronic devices that receive the BAR respond with BA **826**. The source electronic device receives BA **825** and if the source electronic device determines from BA **825** that a sink electronic device failed to receive at least part of PPDU **824**, the source electronic device transmits a unicast copy of the at least part of PPDU **824** to that sink electronic device. In this example, the multicast packets are not retransmitted during the multicast service period.

[0082] Alternatively, the source electronic device may set More Data field (e.g., More Data field **709**) in the MAC headers of MPDUs of a PPDU to a second value (e.g., "0") to indicate that during the remainder of the multicast service period the source electronic device will not transmit more MPDUs addressed to the multicast group and the source electronic device will not request BAs from the sink electronic devices in any following PPDUs. For example, the source electronic device sets the More Data field of one or more MPDUs of PPDU **825** to "0" indicating that no more MPDUs addressed to the multicast group will be transmitted. PPDU **825** can include and/or be followed with BAR from one or more sink electronic devices. The sink electronic devices that receive the BAR respond with BA **827**.

[0083] The source electronic device can set the EOSP field (ESOP field **711**) in the MAC headers of the MPDUs of the last PPDU to a first value (e.g., "1") to indicate to the sink electronic devices that this PPDU is the last PPDU and no more multicast packets are transmitted during the remainder of this multicast service period. For example, the source electronic device sets the EOSP field in the MPDUs of PPDU **825** to "1" to indicate that no more multicast packets are transmitted with the remainder of this multicast service period. By checking that the EOSP field of PPDU **825** is set to "1", one or more sink electronic devices of the multicast group can transition to sleep mode during the remainder of the multicast service period.

[0084] According to some embodiments, trigger frame(s) (e.g., trigger frame **307** of FIG. **3**B) transmitted by the source electronic device can also be used for early termination mechanisms to trigger the sink electronic devices to transition to sleep mode earlier than planned and/or terminate multicast service periods earlier than planned. The trigger frame can include an additional field such as multicast Cascade Indication field (e.g., GCR-Cascade Indication field) used for the early termination mechanisms, according to some embodiments. For example, the added multicast Cascade Indication field can be set to a first value (e.g., "1") to signal the termination of multicast service periods. If the trigger frame indicates the termination of the multicast service period, the triggered sink electronic device may transition to the sleep mode after the triggered sink electronic device transmits it block acknowledgment. The other sink electronic devices (e.g., the sink electronic devices that were not triggered to send block acknowledgments) may transition to the sleep mode after receiving the trigger frame.

[0085] The trigger frame transmitted by the source electronic device can be part of a block acknowledge request (BAR) transmitted by the source electronic device, according to some examples. The BAR is transmitted by the source electronic device to request all or a subset of the sink electronic devices to send acknowledgment(s) of the received multicast packets. According to some examples, although not shown, the BAR can be transmitted after PPDU **815** and before BA **816** of FIG. **8**B, after PPDU **824** and before BA **826** of FIG. **8**C, or after PPDU**2** and before BA **827** of FIG. **8**C.

[0086] According to some embodiments, multicast packets transmitted during the multicast service period can be associated with one group address or different group addresses. The MPDUs within the PPDUs transmitted during the multicast can include and/or be associated with a capability field. The capability field can be included in, for example, a Beacon, Association or other MAC layer management frames. If the capability field of a PPDU is set to a first value (e.g., "0"), the source electronic device indicates that the MPDUs of a PPDU may be associated with one or more group addresses, and the MPDUs of that PPDU have the same More Data field. In this example, a More Data field set to a first value (e.g., "0") may signal that MPDUs from all group addresses have been transmitted once in the corresponding multicast service period, and any MPDUs in that multicast service period are retransmissions.

[0087] If the capability field is set to a second value (e.g., "1"), the source electronic device indicates that the MPDUs of a PPDU may be associated with one or more group addresses, and the More Date field is MPDU specific (e.g., a PPDU may carry MPDUs with different More Data field values to different group addresses.) In this example, a More Data field set to a first value (e.g., "0") may signal that MPDUs associated to a specific group address have been transmitted once in the corresponding multicast service period. Additionally or alternatively, a new bit or a new field in the MAC header may be set to a second value (e.g., "1") to signal that MPDUs from all group addresses are transmitted once in the corresponding multicast service period.

[0088] According to some embodiments, the source electronic device can be configured to prioritize the transmission and/or retransmission of multicast packets depending on different parameters. In one example, when the source electronic device is transmitting multicast packets in multicast service periods and at least one of the sink electronic devices operates in a power save mode, the source electronic device is configured to transmit the multicast packets before any retransmission. Therefore, the sink electronic device in the power save mode can transition to sleep mode after it has received all desired packets, improving its power save performance and reducing delays. In some examples, using request **301** of FIGS. **3**A-**3**B (or other requests), the sink electronic device can inform the source electronic device that the sink electronic device is operating in the power save

mode. During transmission of multicast packets, the source electronic device is configured to determine whether any sink electronic devices operates in a power save mode. In response to a determination that at least one of the sink electronic devices operates in the power save mode, the source electronic device is configured to transmit the multicast packets before any retransmission.

[0089] In some embodiments, if the source electronic device, during a multicast service period, transmits multicast packets associated with different group addresses, the source electronic device can be configured to first transmit the multicast packets associated with the group address, which most sink electronic devices have requested to receive. For example, when receiving requests (e.g., request **301** of FIGS. **3**A-**3**B or other requests) for multicast packets, the source electronic device is configured to determine whether the sink electronic devices request for multicast packets associated with different group addresses. The source electronic device is configured to keep a record of the different group addresses and the number of sink electronic devices requesting each one of the different group addresses. During the transmission of the multicast packets during a multicast service period, the source electronic device is configured to determine which ones of the different group addresses have multicast packets for transmission and the number of sink electronic devices for those ones of the different group addresses. The source electronic device is further configured to determine the multicast packets associated with the group address that most of the sink electronic devices have requested and to transmit those multicast packets.

[0090] FIGS. **9**A-**9**B illustrate an exemplary neighbor report element format, according to some embodiments of the disclosure. FIGS. **9**A-**9**B may be described with regard to elements of FIGS. **1** and **3**A-**3**B.

[0091] As discussed above, source electronic device **110** can include an access point (AP), in some embodiments. AP **110** can be a multiband AP operating at multiple frequency bands. These frequency bands can include, but are not limited to, 2.4 GHz band, 5 GHz band, 6 GHz band, 60 GHz band, etc. AP **110** can be configured to balance traffic in different basic service sets (BSS) by requesting that the associated electronic devices (e.g., electronic devices **120***a-b*) to change their associated BSS to other frequency bands.

[0092] Also, when an unassociated electronic device (e.g., electronic device **120***c*) wants to discover and associate with AP **110**, electronic device **120***c* can determine in which channels (e.g., frequency bands) AP **110** operates and electronic device **120***c* can be configured to determine and select the channel that is most suitable for electronic device **120***c* to associate with AP **110**. AP **110** can be configured to use a neighbor report element in a beacon (e.g., beacon **305** of FIG. **3**B) and/or a response (e.g., response **303** of FIGS. **3**A-**3**B) to communicate to electronic device **120***c* other channels that AP **110** is operating on. According to some examples, electronic device **120***c* can be configured to select the channel most suitable for electronic device **120***c*. Additionally or alternatively, AP **110** can recommend to electronic device **120***c* the channel most suitable for electronic device **120***c*.

[0093] FIG. **9**A illustrates neighbor report element **900**. Neighbor report element **900** can include different fields such as, but not limited to, element identifier (ID) **901**, length **902**, BSS identifier (BSSID) **903**, BSSID information **904**, operating class **905**, channel number **906**, PHY type **907**, and optional subelements **908**. The number under each field of neighbor report element **900** represent exemplary size of the respective field of neighbor report element **900** in bits. Neighbor report element **900** provides multiple BSS information and capabilities and can help the electronic device **120***c* to select a BSS for association.

[0094] According to some embodiments, neighbor report element **900** can be used within system **100** for multicast communication. In other words, multiband AP **110** can use neighbor report element **900** to support multicast communication. FIG. **9**B illustrates an exemplary format of BSSID information **904**, according to some examples to support multicast communication. BSSID information **904** can include different fields such as, but not limited to, AP reachability **921**, security **922**, key scope **923**, capabilities **924**, mobility domain **925**, high throughput **926**, very high throughput **927**, FTM **928**, high efficiency **929**, FR-BSS **930**, GCR-TWT **931**, GC for unassociated **932**, all GC **933**, and reserved **934**. The number under each field of BSSID information **904** represents exemplary size of the respective field of BSSID information **904** in bits.

[0095] According to some examples, GCR-TWT field **931** in BSSID information **904** of neighbor report element **900** can be used to indicate whether the corresponding BSS is capable of transmitting multicast transmissions in multicast service periods. For example, if GCR-TWT field **931** is set to a first value (e.g., "1"), AP **110** indicates that the corresponding BSS is capable of transmitting multicast transmissions in multicast service periods.

[0096] GC for unassociated field **932** in BSSID information **904** of neighbor report element **900** can be used to indicate whether the corresponding BSS is capable of transmitting multicast transmissions for unassociated electronic devices, according to some embodiments. For example, if GCR-TWT field **931** is set to a first value (e.g., "1"), AP **110** indicates that the corresponding BSS is capable of transmitting multicast transmissions for unassociated electronic devices.

[0097] If all GC field **933** in BSSID information **904** of neighbor report element **900** is set to a first value (e.g., "1"), AP **110** indicates that the corresponding BSS is recommended to transmit all multicast transmissions, according to some embodiments. For instance, the electronic devices associating to AP **110** are recommended to request multicast transmissions and set their request (e.g., GCR delivery) for the multicast packets only in this corresponding BSS.

[0098] Alternatively, setting all GC field **933** in BSSID information **904** of neighbor report element **900** to a second value (e.g., "0") may indicate that AP **110** transmits only the multicast transmissions that are needed for network maintenance and service discovery.

[0099] In some examples, AP **110** can be configured to control multicast communications over different channels to optimize traffic over these channels. For example, AP **110** can be configured to indicate within neighbor report element **900** which BSS is used for transmission of multicast packets. In one example, a low frequency band (e.g., 2.4 GHz band) may have a large coverage and AP **110** can use the BSS operating in this low frequency band for transmission of multicast packets. AP **110** can allocate one BSS for transmission of multicast packets for unassociated electronic devices, according to some embodiments. AP **110** can allocate one or more other BSSs for transmission of multicast packets for associated electronic devices.

[0100] According to some embodiments, if AP **110** receives multiple requests for multiple group addressed multicast packets, AP **110** can allocate transmission of each one of the multiple group addressed multicast packets to one BSS. In other words, different BSSs can carry different group addressed multicast packets in order to balance BSSs traffic loads. In one example, AP **110** receives, from a first group of electronic devices, a request for multicast packets associated with a first group address and receives, from a second group of electronic devices, a request for multicast packets associated with a second group address. AP **110** is configured to assign the multicast packets associated with the first group address to a first BSS (e.g., a first one of the plurality of channels) and to assign the multicast packets associated with the second group address to a second BSS (e.g., a second one of the plurality of channels different than the first one of the plurality of channels.) AP **110** is further configured to communicate the assigned BSSs (e.g., the assigned first and second ones of the plurality of channels) to the group of electronic devices and the second group of electronic devices using, for example, neighbor report element **900**. AP **110** may recommend a sink electronic device to change its BSS depending on which one of the multiple group addressed multicast packets the sink electronic device desires to receive.

[0101] FIG. **10** illustrates an example method **1000** for a wireless system supporting implementing TWT process/scheme in multicast communication, according to some embodiments of the disclosure. As a convenience and not a limitation, FIG. **10** may be described with regard to elements of FIGS. **1-9**. Method **1000** may represent the operation of source electronic device **110** of FIG. **1** implementing TWT process in the multicast communication. Method **1000** may also be performed by system **200** of FIG. **2** or computer system **1100** of FIG. **11**.

[0102] At **1001**, source electronic device **110** configures a TWT process/scheme for delivering one or more multicast packets. According to some examples, configuring the TWT process can include receiving a request from at least one electronic device in a group of electronic devices for the TWT process and determining a TWT schedule in response to the request. The TWT schedule can include information such as, but not limited to, a TWT start time indicating when the TWT process begins, information associated with a multicast service period such as the duration of the multicast service period, a repetition interval indicating an interval for repeating the multicast service periods, and a flow identifier indicating that the TWT process is an individual TWT agreement and is associated with delivering the multicast packets.

[0103] Additionally or alternatively, configuring the TWT process can include determining a broadcast TWT schedule. The broadcast TWT schedule can include information such as, but not limited to, a TWT start time indicating when the TWT process begins, information associated with a multicast service period such as the duration of the multicast service period, a repetition interval indicating an interval for repeating the multicast service periods, and a TWT recommendation field indicating a retransmission process associated with the transmission of the multicast packets.

[0104] At **1003**, source electronic device **110** communicates information associated with the TWT process to at least one electronic device. For example, in response to receiving the request from the at least one electronic device in a group of electronic devices for the TWT process, source electronic device **110** transmits a response to the electronic device. The response can include information associated with the TWT process such as, but not limited to, the TWT schedule. In another example, to communicate the information associated with the TWT process to at least one electronic device, source electronic device **110** can advertise information associated with the TWT process such as, but not limited to, the broadcast TWT schedule in a beacon.

[0105] At **1005**, source electronic device **110** determines whether a multicast service period associated with the TWT process has started. Source electronic device **110** can determine the start of the multicast service period based at least on the TWT schedule and/or the broadcast TWT schedule.

[0106] At **1007**, source electronic device **110** transmits the one or more multicast packets to the (sink) electronic device(s). The sink electronic devices can include associated and/or unassociated sink electronic devices. At **1009**, source electronic device **110** may retransmit any of the multicast packets, if needed. Different retransmission modes were discussed earlier. Source electronic device **110** uses one or more of the retransmission modes depending on the configured TWT process.

[0107] At **1011**, source electronic device **110** determines whether the multicast service period associated with the TWT process has ended or whether the remainder of the service period is needed for the frames transmissions. Source electronic device **110** can determine the end of the multicast service period based at least on the TWT schedule and/or the broadcast TWT schedule. At **1013**, source electronic device **110** cease transmission of multicast packets during this multicast service period when source electronic device **110** determines that the multicast service period associated with the TWT process has ended. Source electronic device **110** can implement early termination mechanisms, as discussed in detail above. Source electronic device **110** can repeat **1005-1013** for other multicast service periods of the TWT process.

[0108] Various embodiments can be implemented, for example, using one or more computer systems, such as computer system **1100** shown in FIG. **11**. Computer system **1100** can be any well-known computer capable of performing the functions described herein such as devices **110**, **120** of FIG. **1**, or **200** of FIG. **2**. Computer system **1100** includes one or more processors (also called central processing units, or CPUs), such as a processor **1104**. Processor **1104** is connected to a communication infrastructure **1106** (e.g., a bus.) Computer system **1100** also includes user input/output device(s) **1103**, such as monitors, keyboards, pointing devices, etc., that communicate with communication infrastructure **1106** through user input/output interface(s) **1102**. Computer system **1100** also includes a main or primary memory **1108**, such as random access memory (RAM). Main memory **1108** may include one or more levels of cache. Main memory **1108** has stored therein control logic (e.g., computer software) and/or data.

[0109] Computer system **1100** may also include one or more secondary storage devices or memory **1110**. Secondary memory **1110** may include, for example, a hard disk drive **1112** and/or a removable storage device or drive **1114**. Removable storage drive **1114** may be a floppy disk drive, a magnetic tape drive, a compact disk drive, an optical storage device, tape backup device, and/or any other storage device/drive.

[0110] Removable storage drive **1114** may interact with a removable storage unit **1118**. Removable storage unit **1118** includes a computer usable or readable storage device having stored thereon computer software (control logic) and/or data. Removable storage unit **1118** may be a floppy disk, magnetic tape, compact disk, DVD, optical storage disk, and/any other computer data storage device. Removable storage drive **1114** reads from and/or writes to removable storage unit **1118** in a well-known manner.

[0111] According to some embodiments, secondary memory **1110** may include other means, instrumentalities or other approaches for allowing computer programs and/or other instructions and/or data to be accessed by computer system **1100**. Such means, instrumentalities or other approaches may include, for example, a removable storage unit **1122** and an interface **1120**. Examples of the removable storage unit **1122** and the interface **1120** may include a program cartridge and cartridge interface (such as that found in video game devices), a removable memory chip (such as an EPROM or PROM) and associated socket, a memory stick and USB port, a memory card and associated memory card slot, and/or any other removable storage unit and associated interface.

[0112] Computer system **1100** may further include a communication or network interface **1124**. Communication interface **1124** enables computer system **1100** to communicate and interact with any combination of remote devices, remote networks, remote entities, etc. (individually and collectively referenced by reference number **1128**). For example, communication interface **1124** may allow computer system **1100** to communicate with remote devices **1128** over communications path **1126**, which may be wired and/or wireless, and which may include any combination of LANs, WANs, the Internet, etc. Control logic and/or data may be transmitted to and from computer system **1100** via communication path **1126**.

[0113] The operations in the preceding embodiments can be implemented in a wide variety of configurations and architectures. Therefore, some or all of the operations in the preceding embodiments may be performed in hardware, in software or both. In some embodiments, a tangible, non-transitory apparatus or article of manufacture includes a tangible, non-transitory computer useable or readable medium having control logic (software) stored thereon is also referred to herein as a computer program product or program storage device. This includes, but is not limited to, computer system **1100**, main memory **1108**, secondary memory **1110** and removable storage units **1118** and **1122**, as well as tangible articles of manufacture embodying any combination of the foregoing. Such control logic, when executed by one or more data processing devices (such as computer system **1100**), causes such data processing devices to operate as described herein.

[0114] Based on the teachings contained in this disclosure, it will be apparent to persons skilled in the relevant art(s) how to make and use embodiments of the disclosure using data processing devices, computer systems and/or computer architectures other than that shown in FIG. **11**. In particular, embodiments may operate with software, hardware, and/or operating system implementations other than those described herein.

[0115] It is to be appreciated that the Detailed Description section, and not the Summary and Abstract sections, is intended to be used to interpret the claims. The Summary and Abstract sections may set forth one or more, but not all, exemplary embodiments of the disclosure as contemplated by the inventor(s), and thus, are not intended to limit the disclosure or the appended claims in any way.

[0116] While the disclosure has been described herein with reference to exemplary embodiments for exemplary fields and applications, it should be understood that the disclosure is not limited thereto. Other embodiments and modifications thereto are possible, and are within the scope and spirit of the disclosure. For example, and without limiting the generality of this paragraph, embodiments are not limited to the software, hardware, firmware, and/or entities illustrated in the figures and/or described herein. Further, embodiments (whether or not explicitly described herein) have significant utility to fields and applications beyond the examples described herein.

[0117] Embodiments have been described herein with the aid of functional building blocks illustrating the implementation of specified functions and relationships thereof. The boundaries of these functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternate boundaries can be defined as long as the specified functions and relationships (or equivalents thereof) are appropriately performed. In addition, alternative embodiments may perform functional blocks, steps, operations, methods, etc. using orderings different from those described herein.

[0118] References herein to "one embodiment," "an embodiment," "an example embodiment," or similar phrases, indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it would be within the knowledge of persons skilled in the relevant art(s) to incorporate such feature, structure, or characteristic into other embodiments whether or not explicitly mentioned or described herein.

[0119] The breadth and scope of the disclosure should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

[0120] As described above, aspects of the present technology may include the gathering and use of data available from various sources, e.g., to improve or enhance functionality. The present disclosure contemplates that in some instances, this gathered data may include personal information data that uniquely identifies or can be used to contact or locate a specific person. Such personal information data can include demographic data, location-based data, telephone numbers, email addresses, Twitter ID's, home addresses, data or records relating to a user's health or level of fitness (e.g., vital signs measurements, medication information, exercise information), date of birth, or any other identifying or personal information. The present disclosure recognizes that the use of such personal information data, in the present technology, may be used to the benefit of users.

[0121] The present disclosure contemplates that the entities responsible for the collection, analysis, disclosure, transfer, storage, or other use of such personal information data will comply with well-established privacy policies and/or privacy practices. In particular, such entities should imple-

ment and consistently use privacy policies and practices that are generally recognized as meeting or exceeding industry or governmental requirements for maintaining personal information data private and secure. Such policies should be easily accessible by users, and should be updated as the collection and/or use of data changes. Personal information from users should be collected for legitimate and reasonable uses of the entity and not shared or sold outside of those legitimate uses. Further, such collection/sharing should only occur after receiving the informed consent of the users. Additionally, such entities should consider taking any needed steps for safeguarding and securing access to such personal information data and ensuring that others with access to the personal information data adhere to their privacy policies and procedures. Further, such entities can subject themselves to evaluation by third parties to certify their adherence to widely accepted privacy policies and practices. In addition, policies and practices should be adapted for the particular types of personal information data being collected and/or accessed and adapted to applicable laws and standards, including jurisdiction-specific considerations. For instance, in the US, collection of, or access to, certain health data may be governed by federal and/or state laws, such as the Health Insurance Portability and Accountability Act (HIPAA); whereas health data in other countries may be subject to other regulations and policies and should be handled accordingly. Hence different privacy practices should be maintained for different personal data types in each country.

[0122] Despite the foregoing, the present disclosure also contemplates embodiments in which users selectively block the use of, or access to, personal information data. That is, the present disclosure contemplates that hardware and/or software elements can be provided to prevent or block access to such personal information data. For example, the present technology may be configurable to allow users to selectively "opt in" or "opt out" of participation in the collection of personal information data, e.g., during registration for services or anytime thereafter. In addition to providing "opt in" and "opt out" options, the present disclosure contemplates providing notifications relating to the access or use of personal information. For instance, a user may be notified upon downloading an app that their personal information data will be accessed and then reminded again just before personal information data is accessed by the app.

[0123] Moreover, it is the intent of the present disclosure that personal information data should be managed and handled in a way to minimize risks of unintentional or unauthorized access or use. Risk can be minimized by limiting the collection of data and deleting data once it is no longer needed. In addition, and when applicable, including in certain health related applications, data de-identification can be used to protect a user's privacy. De-identification may be facilitated, when appropriate, by removing specific identifiers (e.g., date of birth, etc.), controlling the amount or specificity of data stored (e.g., collecting location data a city level rather than at an address level), controlling how data is stored (e.g., aggregating data across users), and/or other methods.

[0124] Therefore, although the present disclosure may broadly cover use of personal information data to implement one or more various disclosed embodiments, the present disclosure also contemplates that the various embodiments can also be implemented without the need for accessing such personal information data. That is, the various embodiments of the present technology are not rendered inoperable due to the lack of all or a portion of such personal information data.

What is claimed is:

1. A method, comprising:

configuring a target wake time (TWT) process for delivery of one or more multicast packets to a group of electronic devices,

determining that a service period associated with the TWT process has started; and

transmitting, in accordance with the TWT process, the one or more multicast packets during the service period, wherein the one or more transmitted multicast packets are addressed to the group of electronic devices.

2. The method of claim **1**, further comprising:

receiving, from an electronic device in the group of electronic devices, a request for an individually addressed copy of at least one of the one or more multicast packets; and

transmitting, responsive to the request, the individually addressed copy of the at least one of the one or more multicast packets.

3. The method of claim **1**, wherein the configuring the TWT process further comprises:

receiving, from at least one electronic device in the group of electronic devices, a request to perform the TWT process;

determining a TWT schedule in response to the request, wherein the TWT schedule includes the service period during which the one or more multicast packets are transmitted; and

transmitting, to the at least one electronic device in the group of electronic devices, a response comprising the TWT schedule.

4. The method of claim **3**, wherein the TWT schedule comprises:

a TWT start time indicating when the TWT process begins;

a repetition interval indicating an interval for repeating the service period; and

a flow identifier indicating that the TWT process is an individual TWT agreement and is associated with delivering the multicast packets.

5. The method of claim **1**, wherein the configuring the TWT process further comprises:

determining a broadcast TWT schedule that indicates the service period during which the multicast packets are to be transmitted; and

advertising the broadcast TWT schedule in a beacon.

6. The method of claim **5**, wherein the broadcast TWT schedule comprises:

a TWT start time indicating when the TWT process begins;

a repetition interval indicating an interval for repeating the service period; and

a TWT recommendation field indicating a retransmission process associated with the transmission of the one or more multicast packets.

7. The method of claim **6**, wherein:

the TWT recommendation field, when set to a first value, indicates that block acknowledgment associated with the one or more multicast packets is available for the group of electronic devices;

the TWT recommendation field, when set to a second value, indicates that block acknowledgment associated with the one or more multicast packets is not available for the group of electronic devices;

the TWT recommendation field, when set to a third value, indicates that block acknowledgment associated with the one or more multicast packets is available for one or more unassociated TWT-capable electronic devices; and

the TWT recommendation field, when set to a fourth value, indicates that block acknowledgment associated with the one or more multicast packets is not available for one or more unassociated TWT-capable electronic devices.

8. The method of claim **1**, further comprising:

setting a More Data field in a media access control (MAC) header associated with at least one of the one or more multicast packets to a first value to indicate that consecutive ones of the one or more multicast packets include packets that have not yet been transmitted.

9. The method of claim **1**, further comprising:

setting a More Data field in a media access control (MAC) header associated with at least one of the one or more multicast packets to a first value to indicate that consecutive ones of the one or more multicast packets include retransmission data packets.

10. The method of claim **1**, further comprising:

setting an End Of Service Period (EOSP) field in a media access control (MAC) header associated with a last one of the one or more multicast packets to indicate that no more multicast packets will be transmitted within the service period.

11. The method of claim **1**, further comprising:

determining that at least one electronic device of the group of electronic devices operates in a power save mode; and

transmitting the one or more multicast packets to the group of electronic devices before retransmitting at least one of the one or more multicast packets.

12. The method of claim **1**, further comprising:

determining at least one of a plurality of channels for transmitting the one or more multicast packets; and

informing the group of electronic devices of the at least one of the plurality of channels.

13. The method of claim **1**, further comprising:

receiving, from an electronic device in the group of electronic devices, a request for the one or more multicast packets associated with a first group address;

receiving, from an electronic device in a second group of electronic devices, a request for one or more multicast packets associated with a second group address;

assigning the one or more multicast packets associated with the first group address to a first channel of the plurality of channels;

assigning the one or more multicast packets associated with the second group address to a second channel of the plurality of channels, different than the first channel; and

communicating the assigned first and second channels of the plurality of channels to the group of electronic devices and the second group of electronic devices.

14. An electronic device, comprising:

a transceiver configured to transmit and receive wireless communications; and

one or more processors communicatively coupled to the transceiver and configured to:

configure a target wake time (TWT) process for delivering multicast packets to a group of electronic devices;

communicate, using the transceiver, information associated with the TWT process to at least one electronic device in the group of electronic devices;

determine that a service period associated with the TWT process has started; and

transmit, using the transceiver and in accordance with the TWT process, the multicast packets to the group of electronic devices during the service period.

15. The electronic device of claim **14**, wherein to configure the TWT process the one or more processors are configured to:

receive a request from the at least one electronic device in the group of electronic devices for the TWT process;

determine a TWT schedule in response to the request, wherein the TWT schedule includes the service period during which the multicast packets are to be transmitted; and

transmit a response to the at least one electronic device, wherein the response includes the TWT schedule.

16. The electronic device of claim **14**, wherein to configure the TWT process the one or more processors are configured to:

determine a broadcast TWT schedule that indicates the service period during which the multicast packets are to be transmitted; and

advertise the broadcast TWT schedule in a beacon.

17. The electronic device of claim **14**, wherein the one or more processors are further configured to:

set a More Data field in a media access control (MAC) header associated with at least one of the multicast packets to a first value indicating that a request for block acknowledgment will be transmitted.

18. The electronic device of claim **14**, wherein the one or more processors are further configured to:

set a More Data field in a media access control (MAC) header associated with at least one of the multicast packets to a first value indicating that a request for block acknowledgment will be transmitted for an electronic device within the group of electronic devices that did not receive at least one of the multicast packets.

19. The electronic device of claim **14**, wherein the one or more processors are further configured to:

set an End Of Service Period (EOSP) field in a media access control (MAC) header associated with a last one of the multicast packets to indicate that no more multicast packets will be transmitted within the service period.

20. A non-transitory computer-readable medium storing instructions that, when executed by a processor of an electronic device, cause the processor to perform operations, the operations comprising:

configuring a target wake time (TWT) process for delivering multicast packets to a group of electronic devices, wherein the configuring the TWT process comprises:

determining a TWT schedule in response to a request for the TWT process from at least one electronic device in the group of electronic devices; or

determining a broadcast TWT schedule;

determining that a service period associated with the TWT process has started; and

transmitting, based on at least one of the TWT schedule or the broadcast TWT schedule, the multicast packets to the group of electronic devices during the service period.

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